DISSERTATION

MEASURING THE GAINS FROM INTER-REGIONAL COOPERATION: OVERVIEW AND APPLICATION

Submitted by

Walter R. Schwarm

Department of Economics

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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY WALTER SCHWARM ENTITLED "MEASURING THE GAINS FROM INTER-REGIONAL COOPERATION: OVERVIEW AND APPLICATION" BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

Committee on Graduate Work

Dr. Terutomo Ozawa

Dr. Stephan Weiler

Dr. Stephen Davies, DARE

Dr. Harvey Cutler: Advisor

Dr. Ronnie J. Phillips: Department Head

ABSTRACT OF DISSERTATION

MEASURING THE GAINS FROM INTER-REGIONAL COOPERATION: OVERVIEW AND APPLICATION

This dissertation encompases a tri-fold goal: 1) To explain the theoretical and applied aspects that underlie the construction of a interjurisdictional Computable General Equilibrium (CGE) model. 2) To describe a data organizational method that allows for an easier, more effective model building experience. 3) To construct a CGE model that not only displays the value of regional analysis but also can be used to provide analytical results based on the theoretical structure. Outcomes from this model are analyzed within a game theoretic framework stressing regional cooperation The combined approach allows unusually keen insights into the tradeoffs in a regional political economy. When considering a region-wide policy, such as a growth cap, it may be the case that the jurisdictions' dominant strategy is not the one that maximizes welfare for the component cities.

This game-theoretic argument is tested using a CGE model calibrated to be consistent with the cities and region of Fort Collins, and Loveland, Colorado. By applying the actual dollar/welfare values produced by the model, the relative success of a program of regional cooperation can be evaluated and the relative welfare loss incurred by non-compliance predicted.

Walter R. Schwarm
Department of Economics
Colorado State University
Fort Collins, Colorado 80523
Fall 2002

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Chapter 1

Introduction

Most social and economic activity and opportunity, as well as challenges can be seen to possess a region-wide scope. Such issues include:

- Location of New Firms and Housing.
- Tax Burden.
- Provision of New and Existing City Services.
- Open Access or Annexation Issues.

There are aspects of these issues that cannot optimally be solved by local governments acting independently. Local governmental policies tend to have parochial viewpoints. Yet, there are few governmental agencies that are regional in scope. With the absence of such overarcing organizational entities, no one is considering the welfare of the region as a whole. Therefore, cities are left to work out issues on their own. Cities compete with each other, explicitly or otherwise, for tax base, amenities, land and other resources. Without an overarcing agent, can there be an organizational force?

To such a question, this study answers, "Possibly." If a city within the region develops or asserts regional leadership, then regional organization is an option. With the existence of a leader comes the potential for cooperative determination of cities' courses of action. This may not only lead to greater benefits to the region as a whole but to the individual cities as well. Naturally, there may be some qualifications including: The type of issue, be it fiscal or real, the political climate, and the relative sizes of the cities. This is the core question this study attempts to answer and into which provide some insight.

To examine such issues requires a framework and model. The framework adopted will be a game-theoretic structure which will provide motivation and guidance when examining the aforementioned issues. The model used is a Computable General Equilibrium (CGE) of two towns within a region. The towns chosen were Fort Collins and Loveland, Colorado. The choice was motivated by the idea that either one could represent the "engine of growth" for the region and thus the question of regional leadership adequately addressed.

To address such issues requires a tri-fold approach: 1) To present a theoretical structure wherein regional issues can be analyzed. 2) To describe a data organizational method that allows for an easier, more effective model building experience. 3) To construct a computable general equilibrium (CGE) model that not only displays the value of regional analysis but also can be used to provide analytical results based on the theoretical structure.

The game theoretic structure primarily provides a unifying motivation for examining the issue of a region's growth. Most regions can typically be modeled as an employment center (city), surrounded by a number of smaller towns or bedroom communities. The city and surrounding towns have related issues, yet fundamentally different problems. The city attempts to generate a mix of employment opportunities in the export, or basic sectors and the local, or non-basic sectors such as retail and services. The city must choose the optimal combination of new households and new commercial activities to balance property, sales and use tax revenues. In contrast to these larger towns, smaller towns may have have limited retail, thus the tax base is primarily reliant on property tax revenue, and most decisions emphasize whether to zone for additional residential housing. It is also common that population growth rates are higher in the smaller towns and thus demands on local government services can change more quickly than in a city.

Within such an environment, the question of which city asserts regional dominance has a significant impact on any number of issues such as: commuting pressures, land rents, and infrastructure affordability. Cooperative determination of cities' courses of action may not only lead to greater benefits for the region as a whole, but also to the cities in question. However, this result may well be subject to several conditioning factors, such as the cities' relative importance within the region, the scope of the political decision choice, be it fiscal or real, and the nature of the cooperation. Given the difficulties inherent in such cooperation, can a small city within a regional framework "go it alone" and forge its own policies, independent of its neighbors? Does regional leadership have to be assigned, or can it just happen? These are some of the core questions that will be examined.

While such questions are interesting, they are of little import if the framework in which they are posited cannot be applied. The construction of a CGE model is a complex endeavor, since data first has to be collected and balanced in a social accounting matrix (SAM), and then calibrated in the model. This study presents a methodology that significantly simplifies this process. Utilizing a series of interactive spreadsheets that promote the systematic organization of the data, this method allows the data to automatically create a SAM. The resulting SAM is 95% self-balancing with the remaining changes requiring some adjustments for flows into and out of the city or town economy. This methodology makes it relatively easy, given the data, to construct annual SAMs and CGE models, thereby addressing the major criticism that CGE results' are difficult to generalize since only one year's worth of data is analyzed.

The final focus of this study is the construction of a CGE model of a local regional economy which can be used to provide a quantification of the payoffs resultant from the theory presented in the game theory chapter. Most computable general equilibrium (CGE) models typically describe relatively large geographical regions; as such, they are not able to capture the uniqueness of the cities and towns that comprise the region. In their comprehensive survey of regional CGE models, Partridge and Rickman (1998) maintain that the "relative slow start of regional CGE models is due to the paucity of regional data." On the contrary, this study argues that high quality regional data exists from which very sophisticated CGE models can be constructed.

Many of the issues that towns and cities face uniquely affect each municipality. Any change in zoning that allows more households to move into the city can have a large impact on sales tax revenue, given a well-established retail center. Additional city services, such as police, fire and parks for the new households, can be partially funded from the increased sales tax revenue. However, for a small town with very little retail, the relative impact on sales tax revenue from new households moving into the town would likely be small. As such, the town would have difficulty financing the additional local government services required by the new residents. Any effectual CGE model must be able to uniquely capture such effects.

The results indicate that such an endeavor has real benefit, as, for most cities and towns, the economic impact of similar economic changes can vary substantially. It is such uniqueness that motivates this study, not only in seeking to further understand its basis, but also in developing a methodology that creates a useful policy tool for cities and towns. Indeed, it is only with both the data organization methods and CGE construction techniques, that the game theoretic structure can be analyzed. Without the ability to capture the uniqueness of the individual cities or towns in the study, the game theoretic would remain just that, merely theory. The results suggest otherwise since outcomes are significantly different across cities and towns. Therefore, interesting questions such as those posited by theory can indeed be examined in some detail.

1.1 Outline of Study

Chapter Two initially presents the basis for evaluating regional planning and modeling. This is followed by an examination of potential modeling techniques that might be applicable given the constraints imposed in the first section. Next, there is a discussion and review of some recent models used to study a variety of larger regional economic issues. This chapter concludes with a look at the previous use of such models in examining regional co-operation.

Chapter Three begins by examining some literature on the theoretical basis for regional integration. This theoretical basis is then used to provide the background for the game theoretical co-operational framework. Finally, a more concrete layout of the simulations is developed, including a discussion of the type of situation likely to generate the choice theoretic.

Chapter Four is concerned with the data used in this study. It begins with a description of the data itself, and the primary data sources. An explanation of the sectors used to model the economy follows. The chapter concludes with a description of the social accounting matrix (SAM) framework and the data organization method developed for this study.

Chapter Five is concerned with describing the assumptions and equations of the CGE model itself. Each modeling block described in the previous chapter is translated into equation form and the parameters and restrictions inherent in that translation are described and explained.

The penultimate chapter presents the results of the two sets of model simulations undertaken in this study. The first highlights the sensitivity of the model and examines the differences in the reaction of two cities economies' resulting from an identical stimulus. The second set of simulations, examines the cost of the various scenarios first developed in chapter three's game theoretic. These simulations highlight the regional interlinkages and the effects of the establishment of regional leadership.

The final chapter presents an evaluation of the study's results and an exploration of the limitations of the model. Additionally, directions for future research and improvement are presented.

Chapter 2

Regional Modeling

First, a brief discussion of the evaluation and planning process as it relates to a regional issues. This is followed by the bulk of this chapter; an examination of various approaches used for regional modeling. Finally, there is a discussion of the merits and problems of CGE models and a review of literature using CGE's to study regional issues.

2.1 Evaluation and Planning

The planning process is a rather complicated matter in technical, physical, social, and economic respects. Ideally, when choosing the most appropriate alternative, one would hope that decision makers are guided by a set of rules transforming the details of a certain planning proposal into statements about societal well being (or net social benefits). This set of rules, even if implicit, forms a procedure by means of which the pros and the cons of alternative projects are described in a consistent framework which characterize their various net benefits.

Therefore, an adequate evaluation method requires insight into the formal relationships between the multiple aspects of alternative programs. Another necessity is the clear specification of planning objectives over the set of alternatives. Clear specification ensures that the calculated advantages and disadvantages of a certain plan make reference, not only to the set of planning objectives, but also the set of alternative plans. These conditions imply that social choices and social value judgments are an essential ingredients in each planning procedure: there is no "neutral" planning. Therefore, evaluation (as an integrated procedure of confronting plans with each other) and valuation (as an act of assigning values to project outcomes) play a crucial role in the entire planning process.

Optimum decision making presupposes an unambiguous and clear specification of planning objectives, of planning instruments, and of all constraints imposed on the decision making process. According to Tinbergen (1967), it may be useful to make a distinction between the analytical aspects and the political aspects of public decision making.

The analytical aspect is concerned with the links between the variables relevant to the decision-making process, as well as those side conditions resulting from the economic, social and technological structure of society. Theoretically, the analytical aspect of a decision/problem can have several representations including: a set of formal statements, an impact model, or a structural model. A SAM or CGE model can be seen as fulfilling the analytical requirements of such an analysis.

The political aspect concentrates on the way the instruments should be manipulated to realize policy objectives. What direction or combination of instruments should be used to generate the outcome? What are the consequences of instrument choice and operational timing? A game theoretic structure can contribute answers to these questions.

2.2 Analytical Models

Economic impact analysis using inter-industry models is usually conducted to quantify the economic effects of a proposed project or policy. Economic impact analysis forms a methodology by which the economic implications of a potential action, such as the undertaking of a large infrastructure type investment, or the implementation of a policy or regulation, can be evaluated prior to taking that action. This section briefly summarizes the applicability, structure and limitations of three techniques frequently used in economic impact analysis:

- Using simple Input-Output analysis (I-O).
- Input-Output Econometric Modeling (IOE).

- Computable General Equilibrium Modeling(CGE).

The scope of economic impact analysis should be primarily on the direct effects of the project, for example, the project's investment and operational impacts in terms of number of persons directly employed and contribution to gross product. complemented by the broader economic effects.

2.2.1 Outline of Methodologies

The input-output framework

In economic impact analysis the I-O technique can be considered a limiting case of its more complicated relatives. the IOE and CGE models. In the I-O technique. the I-O table is converted into a model of inter-industry response through the manipulation of the I-O database. Specifically, the values in the I-O table are converted to fixed shares which through the process of matrix manipulation can be used to derive estimates of the total response of the economy as a result of some specified event or policy action. An I-O table is constructed with data on detailed inter-industry flows throughout an economy and information on final demands and total output. as such it is an accounting relationship for an entire economy. with each industry represented as both a column and a row in a matrix. From this matrix inter-industry multipliers can be calculated. By adding a row for payments to labor by the firm, and a column of expenditure patterns (the marginal propensity to consume) to this matrix of inter-industry multipliers, a Leontief Inverse matrix can be derived. The Leontief Inverse matrix captures the three types of economic impact a project will have; the direct impact. the indirect impact. and the induced impact. The direct and indirect impacts capture the effects of changes in final demand. The induced impacts are additional expenditures resulting from increased earnings of local residents as a result of the increase in final demand. The multipliers derived from the Leontief Inverse are then applied to a proposed project to produce estimates of its overall economic impact. I-O analysis involves the use of multipliers to calculate the overall economic impact of a project or policy change. Two types of multipliers are commonly used. Type I multipliers measure the industrial response to the change while Type II multipliers measure in addition to the industrial response the consumption-induced response.

The advantage of the I-O technique is its ease of use and transparency. However, as a methodology for undertaking economic impact analysis the ease of use comes at a cost. In particular, the I-O model is easy to use because of a number of limiting and unrealistic assumptions. One major limitation of the I-O model when used to conduct impact analysis is the use of fixed coefficients implying that an industrial structure remains unchanged by the economic event. In addition, these fixed coefficients imply that the marginal response of industries as a result of some policy action is equivalent to the average relationships observed in the base year for which the tables are compiled.

Another major limitation of the I-O model is its lack of supply side constraints. The implications of this are frequently overlooked in economic impact analysis. Constraints on the availability of inputs, such as skilled labor, requires some means, for example prices, to act as a rationing device. Therefore, prices act as a signal that induces changes in the consumption patterns of producers and consumers. In I-O analysis, where all adjustments take place in changes in the quantities produced, this type of rationing response is assumed not to occur. Consequently, the technique often results in a significant overstatement of the impacts on employment and Gross Product. The lack of supply side constraints also becomes a problem in studies evaluating the impact of government expenditure programs. If the government expands the funding of one program it is faced with the choice of reducing the funding of other programs, raising taxes or undertaking additional borrowing. Either of the last two options would result in reduced expenditure in future periods. Any of these compensating adjustments will act to offset the impact of the initial expansion of government expenditure. These compensating adjustments are not usually accounted for in I-O analysis but need to be included to make these types of evaluations realistic. For these reasons, many, including Bell, Hazell, and Slade (1982), recommended caution in interpreting the results of an economic impact statement using simple I-O analysis. If the flow-on effects are to be incorporated in the impact analysis only the Type I multipliers should be used. It should also be noted that these estimated effects are likely to overstate the benefits of the project to the economy.

As final comment on I-O models, even if an I-O model is applied correctly, the results do not provide any policy prescriptions. Rather a range of policies and a range of projects need to be analyzed using the same model and procedures thereby forming a comparative analysis from which a suitable choice can be made.

Input-output econometric (IOE) modeling

IOE or EC+IO modeling extends the I-O framework by integrating econometric relationships, estimated from time series or panel data, into the I-O framework. The coupled model uses a series of econometric equations to predict key components of regional final demand (i.e. personal consumption, residential/non-residential investment, imports). These final demands then drive a series of input-output equations that trace out the interindustry responses to final demand changes. A second set of econometric equations uses the predicted values for regional output from the input-output model to generate projections of labor demand and income. These projections, in turn, re-enter the original final demand equations to trigger additional rounds of regional interactions.

By incorporating econometric relationships IOE addresses the shortcoming of average relationships in simple I-O analysis and provides the adjustment path of the economy to an economic impact. Additionally, the technique allows the incorporation of supply side constraints. Thus the IOE technique overcomes one of the major limiting assumptions of the I-O model. These constraints are incorporated via econometric relationships that provide an estimate of the price responsiveness of goods as a result of changes in demand and supply. Consumer and producer behavior is affected by these price changes, resulting in changes in the consumption and production patterns.

Notable papers using this technique include Beaumont (1990) who presents a basis for the theoretical unification of the two methods. Swenson and Otto (1998) use the technique to examine the effectiveness of the Iowa fiscal impact model's regional forecasts and their likelihood of political manipulation. Most valuable is Rey (2000) who presents overview of recent research, discusses its impact and gives direction for future research.

Computable general equilibrium (CGE) modeling

The empirical component of the CGE model is an extended I-O table. Each transaction flow in the I-O table is disaggregated into two components, price and quantity. Both the price and quantity components are allowed to adjust, with both components driven by different factors, in response to the economic event being analyzed. In a majority of CGE models used, firms or producers are assumed to maximize profits. In addition, product and factor markets are assumed to be competitive. Profit maximization dictates that firms act so as to minimize costs and factors are generally responsive to price changes. Households are assumed to maximize utility in their consumption decisions, responding to price differences across goods and services. Finally, prices adjust in goods, services, and factor markets to equate demand and supply. The majority of CGE models used commonly can be separated into two broad categories, comparative static and recursive-dynamic. Like the I-O model, the comparative static CGE model does not contain any explicit time dimension. A recursive-dynamic CGE model on the other hand, can be linked to a macro-econometric model to produce a 'business-as-usual' forecast. The resulting CGE model can then be used to trace out a specific time path of the economy following the change in the policy or introduction of the project. The economic adjustment can then be determined by the difference between the two alternative time paths.

In brief, CGEs are general equilibrium models that implement, for better or worse, the text book definition of an economy. There are utility maximizing consumers whose decisions determine the demand for goods and supply of labor. There are profit-maximizing producers whose decision determines the supply of goods and demand for primarily factors and intermediate inputs. There is regional and international trade. There is government which collects taxes and tariffs, may set exchange rates, and provides transfers, subsidies, and services. Finally there are market-clearing conditions balancing supply-demand, which will determine equilibrium prices. The model is "general equilibrium" because all domestic supplies, demands, prices, and income are determined simultaneously within the model. It is "computable" as the model solves empirically for all endogenous variables in a highly nonlinear system of simultaneous equations (Berck, Golan, & Smith, 1997).

2.3 Summary

The previous discussion suggests that the three related techniques when employed in economic impact analysis, will produce markedly different results. The estimated economic benefits derived from an I-O analysis will usually be the most generous. A result attributed to the techniques' use of average rather than marginal responses, lack of supply side constraints and inability to take account of any price responses. In favor of this technique is the transparent nature of the model, making it easy to see how the results were derived, and the fact that in a limiting number of situations more complex models may produce similar results.

It is difficult to compare the estimated impacts of the IOE or CGE modeling techniques since the estimates derived vary from model to model. More importantly, significant variation in estimates can be produced using the same CGE model. This is because the flexibility of these models allows the analyst to incorporate their own professional judgment in determining the appropriate economic environment and initial project or policy specification. In the case of the IOE model, the results will depend very much on the extent to which the supply side of the model is specified and incorporated into the system in addition to the estimated parameters of the model. This will depend on the availability of data and to some extent the preferences of the modeler in the specification of the model. To date, the supply side constraints incorporated in IOE models have not been as complete as those specified in CGE models.

For the CGE model, the estimated response will depend partially on the coefficients used to drive the behavioral relationships specified in the theoretical structure of the model.

but more importantly the economic environment of the model specified in the particular economic impact analysis. For these reasons, the choice of an appropriate methodology for economic impact analysis must be undertaken on a case by case basis. Additionally, it is important that the analysis is presented in a manner in which the assumptions underpinning the results are clear. A rigorous assessment should include sensitivity analysis providing information on how changes in the models' specification, reflecting alternate assumptions, would effect the results.

2.4 A Comparison of Econometric, Input-Output, and CGE Models

The choice of modeling tools used to analyze regional economic issues includes econometric forecasting models, fixed price Input-Output (I-O) multi-sector models, and Computable General Equilibrium (CGE) models. Regional econometric models are criticized for relying on forecasts of national trends as exogenous input variables and restrictive treatment of relations as for example, revenues equal to expenditures, which limit the applicability of theoretically consistent results. The reliance on national trends within these models generally renders them unsuited to examination of the influence of public policies on disaggregated industries or regional welfare effects.

Fixed-price I-O models, or Social Accounting Matrices (SAMs), generally provide more consistent representations of regional economic structure. These approaches are similar to general equilibrium models, however, the assumptions of fixed price models tend to be more restrictive. Such restrictive assumptions as fixed production and consumption functions, unconstrained factor and commodity supply relationships, and fixed or price-inelastic demand for goods and services produce upper bound estimates of exogenous disturbances and errors in the endogenous variables. (Harrigan & McGregor, 1989) Fixed price-models have difficulty in the analysis of supply side relationships, since they are generally designed to study demand side impacts of policy changes, this limits their use in taxation/revenue policy analysis. Fixed price I-O models incorporate a complete accounting of factor payments which, unlike econometric models, does allow analysis of general welfare issues such as policy impacts on household income distribution

CGE models build on I-O models, by strengthening the theoretical basis of modeling and thus enable examination of a wider set of policy issues. The basis of a CGE model incorporates factor and commodity substitution into the structure of production and demand in a manner consistent with modern neo-classical economic theory. A CGE model consists fundamentally of a system of Walrasian equations, representing the clearing of factor and commodity markets resulting from the optimizing behavior of economic agents and institutions. Endogenous prices adjust until factor and commodity market equilibrium conditions are satisfied, consistent with endogenous factor incomes. The endogenous nature of these calculations allows the CGE model to examine factor flows such as commuting and regional consumption interlinkages which would be impossible using either an I-O or SAM. After calibration, or reproduction of, base year data, the system can simulate economic response to changes in policy variables relative to that base year.

In comparison with fixed-price I-O and econometric models, CGE models are more suited to addressing the implications on efficiency and equity of alternative public policies as the underlying assumptions are much more tenable and the results more tractable. The flexibility of various CGE specifications accommodates a wide range of policy variables and adjustment periods. The use of relative factor prices and allowing factor substitution generates a more accurate treatment of the impact of government policies on factor markets and on the distribution of income among regional households. As added benefit, if factor endowments are assumed fixed, the relative efficiency of regional factor utilization can also be compared within the CGE framework.

2.5 Recent Applications

Examples of larger regional studies include: Kraybill and Seung (1999) who examine the impact of public investment in the Ohio economy, Hoffmann, Robinson, and Subramanian (1996) investigate the role of Defense cuts in California, and finally Jones and Whalley (1989) construct a CGE covering most of Canada. Prior attempts in the literature to model specific towns or cities have usually resorted to using artificial data, due to *perceived* data limitations or have relied on theoretical general equilibrium models as a method of analysis. Using artificial data, Kilkenny (1998) examines a two-region model where transportation costs play a significant role in rural development and Anas and Kim (1996) look at the role of congestion in the performance of a city economy. Pasha and Ghaus (1995) and Brueckner and Kim (2000) use a theoretical general equilibrium model to examine optimal taxation (sales and property) policies for a city.

Several of these studies merit further examination as they provide further insight into model construction and the interpretation of results. Berck, Golan, and Smith (1997) construct a CGE model for the state of California, namely the California Dynamic Revenue Analysis Model(DRAM). The authors sought primarily to determine whether or not the net result of tax rate changes is an increase or decrease in tax revenue. Berck et.al.'s model consisted of six primary groups; consumers, producers, government, trade, capital, and labor. The producer group consisted of 28 individually aggregated sectors, grouped according to share of output or disproportionate payment of tax. The households in this model were assigned one of seven classifications corresponding to California Personal Income Tax (PIT) marginal tax rates. The model maintained a balanced budget requirement for state accounts. Thus, a reduction in tax rates led automatically to a higher labor participation rate up to the extent that the increased revenue from higher participation offset the initial revenue loss from lower taxes.

The authors ran simulations designed to analyze the impact of reductions in the Banking and Corporation Taxes (B&CT) and in the Personal Income Tax (PIT). The magnitude of the cuts impact depends greatly upon the ability of labor to migrate and the overall supply of labor. This is unsurprising given the balance budget construction highlighted above. Given the more elastic the supply of labor, the greater the impact of a change in output and tax revenue. Berck et al. examined different elasticities of labor and migration to evaluate the likelihood that a tax cut would pay for itself.

Berck et al. (1997) conclude that a cut in B&CT taxes may be better for the California economy than a cut in the PIT rates. However, in no variant of the model does the tax cut pay for itself; although, it is true that the size of government is reduced, both tax cuts lead to an increase in real economic activity, employment, and investment. Because of the distributional impact of the PIT rate cut, the authors conclude that a cut in taxes on capital may be better for the California economy. Lastly, the model shows that with perfect factor mobility, tax policy in California can only affect the size of the economy and cannot affect after-tax wages or returns to capital.

Morgan, Mutti, and Rickman (1996) use a nonlinear six region (Great Lakes, New England-Mideast, Plains-Rocky-Mountain, Southeast, Southwest, Far West), seven sector, four factor general equilibrium model of the United States to assess the viability of policies related to the long run exporting and importing of regional taxes. Particular attention is focused on interregional factor movements and their implications for changes in regional tax revenue and demand for regional public goods. To measure welfare changes, the authors propose two different criteria: welfare of the original residents residing in the region and welfare of the regional residents (including newcomers) after the tax policy change is adopted. In either case, welfare measurement is defined as an increase in consumer expenditure. Two policy changes are analyzed: the substitution of current regional business and household taxes for a non-exportable lump-sum tax (Alternative I), and the substitution of current taxes for a household tax (Alternative II), where substitutions are of equal yield. These substitutions are applied multilaterally, or simultaneously for all regions, and then unilaterally, or one region at a time.

The authors find in both tax scenarios that the Great lakes region is the major net tax exporter when regions act unilaterally, whether or not labor is geographically mobile. When taxes are adjusted multilaterally, economic growth always occurs in the Great Lakes region and so does welfare improvement, except for the original residents with labor mobile. The more favorable results for the Great Lakes region are explained by the relatively larger importance of manufacturing, its tax structure, and its debtor status. For the other regions, the pattern of net tax exporting depends on the alternative tax chosen and on factor mobility. In these regions, there is no close relationship between regional growth and the welfare of its original residents. In the lump-sum tax scenario with mobile labor, the Northeast and the Far West are net tax exporters and the welfare of original residents rose; however, value added and welfare of the **ex post** residents residing in these regions decline. Conversely, the three tax importing regions experience gains in output and **ex post** regional welfare, but the welfare of the original residents declined.

Kraybill and Seung (1999) perform a study of the effects of a reduction in the corporate tax in Ohio. They employ a dynamic CGE structure, wherein the results from one stage are reentered as starting values for the second stage. This iterative procedure allows them to examine the effect of tax policy changes and trace out the response time of the Ohio system. Significantly aggregate welfare gains/losses are measures as the aggregate percent change over time as compared to the calibration benchmark. Their estimates of welfare changes are based primarily on the sum of the stream of the present discounted value of the change in per capita expenditures. The model nicely illustrates capital and labor accumulation as influenced by regional policy as well.

2.6 Regional Dynamic CGE Models

There have been hundreds of CGE models built and used to analyze public policy at the national and international levels, but relatively few at the regional level. Regional CGE models are similar in design to the national and international models, but exhibit major differences. Berck et al. (1997) summarize these difference as follows: First, regional models do not require the regional savings to be equal to regional investment. When local residents save more than local investors want to use, excess savings flow out of the region, so too for smaller areas. Second, regional economies trade a large share of their output. Therefore trade is more important in the regional setting. The Third difference is that regional economies face larger volatile immigration flows than nations. Hence migration is a major factor to economic growth in the regional economy model compared to the national model. The Fourth difference is that regional economies have no control over monetary policy. As a result, in regional models taxes are interdependent through deductibility from income constrained by local regularities.

Partridge and Rickman (1998) in their survey of regional CGE models, discussed the contribution of such modeling techniques toward economic analysis, and outlined the typical regional modeling technique. The paper lists over 30 regional studies and summarizes each model's production inputs, mobility of capital, labor, and energy and the status of labor market closure in each study (between market clearing wage setting, exogenous wage rate, or scenarios for both). The study explored the strengths and weaknesses of published applications of regional CGE models focusing on areas of interest such as regional effects to changes in final demand, tariffs and federal fiscal policies, agricultural and environmental policies, regional fiscal policies, and transportation policies. The paper concludes with suggested future directions for research in regional CGE modeling. These suggestions include using flexible functional (FFF) forms such the Translog or Generalized Leontif alternatively to CES functional forms as the FFF have the advantage of allowing substitutability between factors of production in addition to allowing a degree of complementarity between some factors such as energy and other factors.

2.7 Critique of Computable General Equilibrium Models

One of the most significant critiques of CGE modeling concerns the underlying assumptions imposed on the "economy" by the functional forms chosen to represent it. Almost all studies use the following underlying assumptions with respect to the production function: constant return-to-scale, neutrality of technological change, and profit maximization in perfectly competitive markets. The measured impact of technological and factor market change varies considerably between these studies.

Many applied general equilibrium models tend to be either based on single period optimization assumptions or use the CGE structure in a discrete sequential manner to model dynamic processes. Harris' (1984) work is considered by many as the first successful and compelling general equilibrium model to incorporate both imperfect competition and increasing returns to scale. His work deals with a small open economy and formulates for the first time the modeling of IRS using the dual approach. After Harris's work, imperfect competitive general equilibrium models have been extensively used, especially in trade liberalization issues.

Imperfect market structures that characterize the product side of the production system have been the major focus of the majority of theoretical and empirical work. Monopolistic competition and oligopolistic competition, for example, have extensively been applied in trade models. However, market imperfections related to the factor (input) side of the production system remain unexplored. The prevailing reason seems to be the international trade focus of most national CGE models where factor market imperfections are of less concern: i.e., how strong is the case for monopsony modeling when commodities are traded nationally and internationally? This is however not the case when examining smaller areas such as a region, with such models.

The primal approach in modeling increasing returns to scale has been infrequently used by CGE modelers. The reason is the indeterminacy under increasing returns to scale. Kilkenny (1998), however, argues that "when factor markets are geographically segmented and the pool of labor is limited, factor costs will rise for an industry which is expanding operation, using unexploited increasing returns to scale." In this way the existence of an optimal output level is obtained.

Nevertheless, it is true that CGE analysis can seem like a black box approach, although that charge may well be levied at almost any mathematical or econometric analysis. CGE models are fundamentally theory with numbers, and are therefore subject to the current state of the theory used to create them. They are adequate to explain issues that have mostly a static nature such as the impact of trade, fiscal policy, factor flows, the distribution of income between regions or factors, and the distribution of employment among sectors. CGE models are not as good at examining the causes of growth and the dynamic welfare effects of changes over extended periods, but than again few models are.

2.8 Conclusion

The literature reviewed above provides justification and basis for investigating the nature and benefits of interregional cooperation. That benefits should occur, has relatively strong backing within theoretical literature. Such benefits, if they do occur, can clearly be acceptably measured without the need of a social welfare function. Equally there is sufficient support within the literature for the use of the CGE modeling environment over the econometric and input-output techniques when considering such issues. Furthermore, previous research supports the basic use of CGE results, namely income, consumption and employment, as acceptable benchmarks for welfare.

However, the current CGE models discussed above, are much too aggregated to be of use to towns and cities. For example, consider the economic consequences of a manufacturing firm of 250 employees locating in a city of 100,000 people verses locating in a town of 5000 people. The impact on the wage structure in the city will be relatively small given the size of the workforce, however, the impact on the wage structure in the town could be very large. The difference in relative wages across the city and town will lead to differences in household migration, commuting and land use zoning. Attempts to model smaller economic areas, much less cooperation among inter-regional entities have so far not appeared in the literature at the level and sophistication of this study and such modeling therefore forms this studies most basic contribution to the literature.

Chapter 3

The Game-Theoretic

Strategic interaction is a key element in recent models of local government behavior. Interaction occurs because the market environment in which local policy decisions are made is affected by the actions of other local governments. Policy choices are thus interdependent and the resulting interaction must be taken into account in characterizing the public sector equilibrium.

Models with strategic interaction have found their widest use in the tax competition literature. At their most basic such models feature communities financing public spending with a tax on mobile capital, and since capital migrates to equalize after-tax returns, the allocation of capital depends on tax rates in all communities. A variety of studies starting with Mintz and Tulkens (1986) and Wildasin (1988) have examined the basic premise and the resulting underprovision of public goods. Following these early papers Hoyt (1991) and Wildasin (1991b) among others explore variants of the basic model. Hoyt (1993) and Wilson (1995) add a richer menu of tax instruments and perhaps more importantly for this study, consumer mobility. Additionally, Helsley and Strange (1995) study strategic interaction in the choice of urban growth control measures. Beyond these theoretical studies, Case, Rosen, and Hines (1993) , Belsley and Case (1995) and Brueckner (1998) provide the only empirical studies of strategic interaction among governmental units.

Within this literature, individual cities are large relative to the urban system, consumers are mobile across cities, and preferences embody a negative population externality (people prefer small to large cities). Land rent escalation derives from two sources: supply restriction and amenity creation. The first effect arises because one city's land area restriction appreciably limits the supply of urban land, driving up land rents throughout the system. In addition, the smaller population achieved by the restriction makes the city more attractive to consumers, and this amenity gain is partly capitalized in local rents.

Regional coordination problems can be modelled in several different ways. One framework is that of the classic Prisoners Dilemma(PD) game. This game is the standard representation of externalities where, in the pursuit of their own private gains, actors impose costs on each other independent of each other's actions. Town A will choose its dominant strategy and town B will pick its dominant strategy. Both towns are worse off than if both had abstained from pursuing their narrow self-interest and cooperated, thereby reaching a higher payoff. The dilemma persists even if cooperation is achieved because both towns will continue to have strong incentives to defect.

3.1 Coordination Games

Coordination games are generally less well understood as examples of collective action. They raise different problems from PD games. As Snidal writes:

> "The problem in PD is that in pursuing its self-interest, each (town) imposes costs on the other independent of the other's policy, whereas in the coordination game each imposes costs or benefits on the other contingent upon the other's policy. The collective action problem is that neither (town) can choose its best policy without knowing what the other intends to do, but there is no obvious point at which to coordinate." (Snidal, 1995)

Returning now to the two towns, A and B, with the additional assumption that there are good incentives for them to grow. Indeed one might argue from within a self-interest/social choice framework that they must grow. However, it is also true that the region which the cities inhabit has a carrying capacity and the closer they come to that capacity, the more likely the losses associated with growth will be greater than the gains. If the two towns are given only two choices, share plans (agreement) or go-it-alone, a matrix such as the coordination game illustrated in Table 3.1 can be posited. As presented, the towns have three courses of action open to them: Form a shared plan (Agree, Agree), engage in tacit agreement by following the other's lead (Go-it-Alone, Agree) and (Agree, Go-it -Alone), or pursue blind self-interest (Go-it-Alone, Go-it-Alone). Once a solution is achieved, it is self-enforcing, though not optimal. Neither town has an incentive to defect. In other words, the problem of the coordination game is one of choice between multiple equilibria which are stable and efficient but over which the towns have opposed interests; whereas in the PD game, the problem is how to get away from a single stable, inefficient equilibrium. This dilemma is particularly cogent if this situation is not treated as a single shot game, but rather, more realistically, as repeated play.

Table 3.1: Theoretical Game Outcome

		Town B	
		Agreement	Go-it-Alone
Town A	Agreement	(4, 2)	(0, 7)
	Go-it-Alone	(8, 0)	(-4, -5)

Typically, the collective action problem underlying an n-person coordination game is solved if there is one town (a regional leader) whose membership or cooperation in the group is perceived, by all or by a majority, to be more important to the group than that of any other town. Regional leaders can also help to ease distributional issues which arise as coordination games are iterated. Repeated play makes coordination more difficult since players now have an incentive to be more concerned with the distributional consequences of coordination. If (Go-it-Alone/Agreement) is the repeated outcome of an iterated coordination game, Town A will be quite satisfied, whereas Town B only gets a second-best solution. Additionally, small differences accumulate over time. Questions of fairness and the equitable distribution of the gains from cooperation must be addressed to prevent discontent from increasing and leading to an eventual defection. A dominant member town or a regional grouping may be able to assume the role of regional paymaster, easing distributional tensions and thus smoothing the path of integration. The need to have a regional leader to ensure a stable solution, provides an argument for explicitly modelling such an arrangement.

As argued above, in repeated play, neither strategy defeats the other thus the evolutionary equilibrium will be a mixed strategy of $\frac{5}{13}$ Agreement and $\frac{8}{13}$ Go-it-Alone. However. this is a relatively costly equilibrium as (-4, -5) comes up quite often. Given the greater costs that this equilibrium places on Town B. it is in its best interests to modify its behavior and allow Town A to lead. There are established theories of leadership which may be modified to provide a model of such leadership, and the Stackelberg oligopoly model is employed hereafter.

3.2 Explicit Regional Leadership

The preceding analysis is fundamentally based on strategic interaction due to "spillovers", be they of a benefit, or cost nature. Following Bruckener (2001) and Figlio, Kolpin, and Reid (1999), the basis of such interaction may be characterized as follows: Each jurisdiction i chooses the level of a decision variable z_i, but the jurisdiction is also directly affected by the z's chosen elsewhere, thereby indicating the presence of spillovers. Thus, jurisdiction i's objective function may be written

$$V(z_i, z_{-i}; X_i). \tag{3.1}$$

where z_{-i} is the vector of z's for other jurisdictions and X_i is a vector of characteristics of i. which help determine preferences.

Jurisdiction i chooses z_i to maximize 3.1, setting $\partial V/\partial z_i \equiv V_{z_i} = 0$. Because this derivative depends on z_{-i} and X_i, the z_i solution depends on choices elsewhere and on jurisdiction i's characteristics. The solution can thus be written

$$z_i = R(z_{-i}; X_i) \tag{3.2}$$

The function R represents a ***reaction function***, which gives jurisdiction i's best response to the choices of other jurisdictions. Note that the position of the reaction function depends on jurisdiction i's characteristics.

Given this most simple interaction framework, one can examine the "resource-flow" model as a more apt example. In this model, a jurisdiction is not affected directly by the z

levels in other jurisdictions, but by the amount of a particular resource that resides within its borders. Because the distribution of this resource among jurisdictions is affected by the z choices of all, jurisdiction i is indirectly affected by z_{-i}. In this model, agent i's objective function can be written

$$\tilde{V}(z_i, s_i : X_i), \tag{3.3}$$

where s_i is the resource level enjoyed by i. The distribution of resources depends on the entire z vector as well as on jurisdiction characteristics. Thus, the resources available to i are given by

$$s_i = H(z_i, z_{-i} ; X_i). \tag{3.4}$$

Note that since X_i can be measured relative to the average characteristics of all jurisdictions, X_{-i} need not appear in 3.4.

To derive the reduced form of the resource-flow model, 3.4 is substituted into 3.3, yielding

$$\tilde{V}(z_i, H(z_i, z_{-i} ; X_i) ; X_i) \equiv V(z_i, z_{-i} : X_i). \tag{3.5}$$

Thus, even though the underlying model is different, this objective function has the same form as 3.1, with z_i, z_{-i} and X_i appearing as arguments. As a result, maximizing 3.5 by choice of z_i yields a reaction function like 3.2. The properties of this function are now more complex, with its slope depending jointly on the properties of the H and $\tilde{V}$ functions.

For this study, land is the resource s. Land prices and availability affects not only the arrival of new firms and households, but also existing firms and households due to changing rental prices. Changes in the policies of a jurisdiction affect the amount people bid for housing there. Those policy changes affect the price of housing both in the jurisdiction and in other jurisdictions because of interjurisdictional movements of capital and residents. Because changes in a jurisdiction's housing prices affect its tax base, population, and the cost of its residents' housing these price changes must be considered when choosing a policy and responding to the policies of other jurisdictions.

Since regional leadership and co-ordination do not spontaneously arise out of a vacuum. the problem of leadership is examined assuming that the local government is in control of the situation. Cities have several control variables at their disposal including taxes. zoning, or outright cash incentives. For the purpose of this study and its focus on land. tax revenue generated through property taxes will figure prominently. Thus we have tax revenue T which is a function of the tax rate τ, which corresponds to z from above. and the price of land derived from a demand relationship. So, given land quantities q_A and q_B we can write the following analogous to 3.4:

$$P_{land} = f(q_A + q_B)$$

$$T = \tau P_{land}$$

Thus:

$$T = \tau f(q_A + q_B)$$

Each town's revenue depends on its own land quantity and the its own price of land which is dependent on land quantity in both towns.

$$R_A = T_A = q_A \tau_A f(q_A + q_B) = T_A(q_A, q_B) \tag{3.6}$$

$$R_B = T_B = q_B \tau_B f(q_A + q_B) = T_B(q_A, q_B) \tag{3.7}$$

Rather than profit, net tax revenue over expenses is used. where the cost of land. C_i. reflects characteristics of the town, X_i from 3.3, for example: increased demand for city services such as roads, wastewater. utilities and so forth.

$$\Pi_A = T_A(q_A, q_B) - C_A \tag{3.8}$$

$$\Pi_B = T_B(q_A, q_B) - C_B \tag{3.9}$$

Net tax revenue can be used by the town government for a variety of purposes. to expand. increase pay, or enlarge its influence.

Since neither towns' revenues are independent, nor are their land use decisions, the usual reaction functions can be posited:

$$q_A = \Psi_A(q_B) \tag{3.10}$$

$$q_B = \Psi_B(q_A) \tag{3.11}$$

which fulfill the property that town A maximizes Π_A given a specified value of q_B, and vice-versa. If the condition that town A is the leader is imposed, then A's conjectural variation $\partial q_B / \partial q_A$ with B is assumed known and valid. Therefore, the reaction function can be written:

$$\Pi_A = T_A(q_A, \Psi_B(q_A)) - C_A. \tag{3.12}$$

This reaction function contains all the information necessary to link together government land use decisions between the two towns. Theoretically, the model can now solve for all the possible interactions between the towns in the form of the following table:

Table 3.2: Theoretical Modelling Outcomes

		Town B	
		Agreement	Go-it-Alone
Town A	Agreement	Stackelberg Solution	Town A unreactive to B
	Go-it-Alone	Town B unreactive to A	Stackelberg Disequilibrium

As can be seen in Table 3.2 the situation between the two towns has three types of outcomes. The first is that of Stackelberg equilibrium, where one city is either by mutual choice or historical chance is seen as the regional leader. In this case, the reaction functions described above, function as expected, and the two cities achieve a kind of easy truce which benefits them both. The second outcome involves the breaking of the agreement, be it tacit or explicit, wherein Town A and Town B both choose to compete for the firm and the housing that it attracts. In this case the region experiences either a bidding war or attempts by both towns to rezone sufficient land for both projects. This situation, where both cities have chosen to lead, degenerates into Stackelberg disequilibrium, or economic warfare. Equilibrium is established only after the "weaker" town is eliminated (which is to say a political regime shift occurs), or succumbs to the leadership of the other.

The third type of outcome is more difficult to characterize. This outcome is represented by the off-diagonal elements of Table 3.2. These can be seen as Nash-equilibria for the region, if the two cities adopt inward looking policies and do not consider the existence of the other city at all. These outcomes serve as a kind of baseline case, as what the outcome would be if the decision of the firm and households were unaffected by city controls.

Thus, the above reaction functions, combined with the regional interlinkings present in the CGE model described in the next chapters, allow one to calculate the true dollar value of the payoff matrix presented in Table 3.1.

Chapter 4

Data Collection and the SAM

To construct the model, data was collected on population, employment, wages earned, output, capital stock, land use and services supplied by the cities and county in the study. To meet this objective, the two cities, Larimer county, the county assessor's office for Larimer, and several state agencies were contacted. The type and nature of data collected and the context of its use in the model is outlined in the following sections.

4.1 Geographical Dimensions of the Study

The cities and towns involved in this study are Fort Collins and Loveland. Table 4.1 presents a general description of these Larimer county cities. As can be seen Fort Collins is the largest city with a population more than twice that of Loveland. Table 4.1 also presents employment in the seven labor groups and the number of households in the six categories across the towns. This data was computed using 1990 census data and updated to 1998 using information from the state demographer.

4.2 Employment and Wage Data

The Colorado Department of Labor collects data on the number of workers in each sector as well as the wages paid to those workers. This data is collected from two different perspectives: ES-202, and unemployment insurance (UI). ES-202 data summarizes quarterly reports by firms about the number of workers employed for a quarter and the total wage bill paid for those workers. Theoretically, every private employer is required to supply this

Table 4.1: Summary Statistics for the Modeled Towns

	Ft. Collins	% of Total	Loveland	% of Total
Total Population	105,000		53,560	
<$5000	16787	26.12%	5917	23.38%
$5k-$10k	8884	13.82%	2895	11.44%
$10k-$20k	11102	17.27%	4916	19.43%
$20k-$30k	10114	15.73%	6305	24.92%
$30k-$40k	6160	9.58%	2860	11.30%
$40k-$50k	4042	6.29%	1096	4.33%
$50k-$70k	3839	5.97%	847	3.35%
$70k+	3353	5.22%	467	1.85%
Total Employment	64281		25303	
Commuting Out	14647		14255	
Commuting In	15240		12143	
# IN HH1	3491	8.70%	538	3.19%
# IN HH2	5197	12.95%	2019	11.96%
# IN HH3	8972	22.36%	4551	26.95%
# IN HH4	2981	7.43%	1774	10.51%
# IN HH5	8595	21.42%	3745	22.18%
# IN HH6	10883	27.13%	4259	25.22%
Total # HH	40119		16886	
Total City Income (Mil $)	87.38		30.66	
Gross City Product (Mil $)	2331.72		682.31	

information and this data is collected on a town-by-town basis. In addition, every worker in the private sector has a UI number, which allows the state to track the individual wages earned by that worker for every quarter. Thus, the state can identify the firm that each worker is employed by and multiple job holders can be identified by social security numbers appearing more than once. Combining the ES202 and UI data, allows one to create a distribution of employment and wages (Table 4.2) useful for modeling purposes in the CGE. The addition of estimates of commuting into and out of each city, obtained by feeding Census time-to-work data through a gravity model to determine quantity and location, further specializes the data.

The net result is that the impact on the distribution of employment and wages in the factor markets can be evaluated under a wide range of scenarios.

There are several employers that are not covered in the ES-202 and UI programs, such as school districts and local, state, and federal governments. It was necessary to contact these entities separately to obtain their wage and employment data. In addition, single proprietors must also be accounted for and added to the data set.

Table 4.2: The Sectors and the Economy

Profit Maximizing Sectors(1-15)	
1) Agriculture services	10) Transportation and utilities
2) Agricultural production	11) Communications
3) Agricultural processing	12) Wholesale
4) Low services: hair, cleaners, etc.	13) Retail
5) High services: legal, medical	14) Finance, insurance & real estate
6) Construction	15) Forestry and Fisheries
7) Manufacturing	
8) Mining	16) Universities and JCs
9) Computer Manufacturing	17) School District
Housing Market	**Public Sectors**
HS1 < \$120,000	1) Local Utilities
\$120,000 < HS2 < \$200,000	2) Local City Government
\$200,000 < HS3	3) State and Federal Governments
Labor Groups	**Household Groups**
$L_1 < \$5,000$	HH1 < \$10,000
$\$5,000 < L_2 < \$10,000$	\$10,001 < HH2 < \$19,999
$\$10,000 < L_3 < \$20,000$	\$20,000 < HH3 < \$39,999
$\$20,000 < L_4 < \$30,000$	\$40,000 < HH4 < \$49,999
$\$30,000 < L_5 < \$40,000$	\$50,000 < HH5 < \$69,999
$\$40,000 < L_6 < \$50,000$	\$70,000 < HH6
$\$50,000 < L_7 < \$70,000$	
$\$70,000 < L_8$	
Capital Stock	**Land**
K_1 - buildings and factories used by the productive and public sectors	$Land_1$ - land used by the productive sector
K_2 - computers, machines used by the productive and public sector	$Land_2$ - land for residential homes
	$Land_3$ - undeveloped land for commercial and residential use

4.3 Households

Households have two primary roles within the model. First they provide the direct consumption of goods and services from the productive sectors. Secondly, some proportion of the households provide labor to the productive sectors for which, in-turn, they receive income.

Fully determining the expenditure patterns of the six households requires combining three sources of data. The first source is IMPLAN, a private firm that provides estimates of economic activity for every city and county in the U.S. IMPLAN provides estimates of how much each household spends annually in 528 different sectors. The IMPLAN expenditures sectors were aggregated to correspond to the 17 sectors in the model. The IMPLAN and SIC code aggregation template used in this study is found in Appendix B. The U.S. government also provides estimates of household expenditures in the Consumer Expenditure Survey. When combined these two sources provide a good representation of consumer expenditures across the cities in this study.

Besides purchasing goods and services from each sector, households also make expenditures for housing. The third source of data, housing values, was obtained from the Larimer county assessor's office. Modelling the housing market presents some challenges because it does not produce output like the private sectors but owning a house does provide a service in terms of meeting the needs of a family. The housing sector was modelled from two perspectives: 1) As any other expenditure, since households make annual payments for their mortgage or rent, and 2) Housing as providing a service to homeowners. Therefore, a relationship exists between what households pay for their home on an annual basis and the services that they obtain from the property. The integration of these two ideas provides for a more complete analysis of the housing market.

Household savings can be divided into two components: the first is non-voluntary savings automatically allocated to social security or some other form of retirement; the second component is savings made in addition to the required savings. For this model, only households 5 and 6 (HH5 and HH6) command enough income to have positive savings.

The final component of expenditures is federal and state taxes. For instance, in A the variable USPIT describes the personal income taxes that each household has to pay to the state and federal governments. The household also makes expenditures for property tax, referred to as CNPRP. In addition, the household will also make expenditures for services provided by the city such as recreation, the arts, fines etc. these are lumped together as CYORV.

The household income stream is derived from several different sources as well. The primary source is labor income. In addition, households receive income from social security, retirement, and appreciation of homes and investments. These sources are also taken into account in the model. The resulting labor, land and capital income is then mapped into the six different household groups, defined as per Table 4.2. The mapping procedure relies on census data as well as some estimates provided by the state demographer on the distribution of household income. Jim Weskott, the state Demographer for Colorado was very helpful in supplying data and interpreting a wide range of data issues for this study. The number of multiple income earning households present in the model is also determined at this point, yielding the 'JOBCOR' statistic, or the number of wage earners per household.

The calculation of household expenditures across sectors requires both, the distribution of expenditures as well as, the level of expenditures. Distribution patterns were estimated using a combination of IMPLAN data and the Consumer Expenditure Survey. Both of these sources offer levels of expenditures across household groups, but need to be reconciled with the level of estimated labor, land and capital income from above. Additional wealth that supports expenditures, such as stocks and outside remittances are also used to obtain consistency between expenditures and income.

4.4 Capital and Land

The standard county assessor's office is likely to keep good records on the use of each parcel of land in the county, since property taxes differ across commercial and residential parcels. Using the imbedded abstract codes allows one to allocate the commercial parcels into most of the private sectors presented in Table 4.2. Included in each parcel are data on acreage and the market value of the structure (capital) on the parcel, therefore very good data can be obtained for value added in the profit maximizing sectors. Data is also collected on personal capital (computers, production lines, etc) however this particular data may have accounting concerns given its link to depreciation values.

Similar data are also available for residential properties. The county collects data on market values for the acreage and the house on each parcel and these values are used to compute the housing expenditures for our six household groups. As Table 4.2 indicates, homes are divided into three categories determined by prices and there is a sector for multiple unit housing.

4.5 City and County Data

The data collected from a local government for a city, town or county comprises employment and wages, non-labor expenditures for city services and the range of taxes collected by the local government. The cities in the study were typically divided into five categories: the police department; the fire department; the transportation department; city administration; and library, parks and recreation. Employment and wages for each of these departments were collected as well as the non-labor expenditures made by each department.

Governmental transfers, revenues, and financial gains on investments were combined with the revenues derived from businesses and individuals in the communities. These revenues, were grouped in the model as the category General Revenues. Additional revenues generated from public utilities and public facilities, namely Special Revenue Funds and Enterprise Funds, were accounted for and divided amongst the appropriate sectors.

The most challenging government category is the school district. Some school districts are responsible for the residents outside of town, or towns may be split between districts, so it can be difficult to determine the appropriate school district. The problem is confounded by the fact that accuracy of school district information is doubly important due to the size of the entities. Often times school district budgets are considerably larger than the remaining budget for the town. Despite these issues, employment and wage data, as well as non-labor expenditures, for school districts were determined and included in the model.

The information gathered for the cities derives from numerous sources, including county, city and school district audits, planning departments, and personnel departments. The revenues for the cities and towns in the study came from a variety of sources as well, chief among these were property taxes. One of the main difficulties encountered here was separating the property taxes paid by businesses from those paid by households. Separation was performed using the tax information supplied by the county assessors office and the cities and towns in the study. In addition, many of these same sources were used to compute sales and use tax revenues, as well as charges for services, fees and other payments made by the residents and businesses in each city and town. For several of these revenue sources, it was necessary to isolate the funds collected from business interests from those collected from local residents.

For each government entity, the same kind of data required for private firms is required. First, labor and material expenditures are required, ideally categorized by the type of service provided. Such data are usually easily obtained from city computer databases. Unlike firms, the types of revenue sources and amounts are also needed, and would be best tied to functional categories. For instance, taxes collected for schools are specifically related to education; fees for parks and recreation are related to local services in that area, etc. Much of this information is reported in the certified annual financial reports (CAFR), and thus the CAFR may be seen as the primary initial data source for the government.

4.6 The SAM

While the sections above describe the basic data components of the model. the social accounting matrix (SAM) ties all the data together in a logically consistent manner. Figure 4.1 presents the general SAM structure as used for this project. In the following, blocks

Receipts ⇓	Payments ⇒					
	Commodity (1)	Factors (2)	Households (3)	Governments (4)	World (5)	Total (6)
Commodity (1)	Intermediate Inputs		Consumption & Investment	Consumption	Exports	Total Commodity Output
Factors (2)	Value Added				Foreign Value Added	Total Factor Income
Households (3)		Distribution of Value Added	Savings	Transfer Payments	Foreign Transfers & Savings	Total Institutional Income
Government (4)	Use and Sales Taxes		Income and Property Taxes	Inter-Gov Transfers		
World (5)	Imports					Total Imports
Total (6)	Total Commodity Outlay	Total Factor Outlay	Total Institutional Expenditures		Total Exports	Gross City Product

Figure 4.1: The Partial SAM

within the SAM will be referenced by the row and column numbers below the row and column headings. As an example column 1, row 1 refers to the block labeled intermediate inputs.

The SAM ties together all the expenditures made by a sector to the receipts of that sector. Column 1 (commodity) represents the private sectors. and summing down the column represents all the expenditures that each sector makes as it produces goods and services. The first expenditures are the commodities that the industry demands from the other sectors, commonly referred to as intermediate demand. The second expenditure is factor demand (labor, land and capital). Next expenditures for use, property and sales taxes and other costs of doing business are accounted for. The vertical summation of these components represents the dollar value of domestic supply for that sector. The last expenditure made by the private sectors are imports, which are located in the bottom row. The row designated commodities represents the supply of goods and services to other sectors, households, the government sectors and the last column, exports.

In a similar fashion, the household column represents the allocation of household income to consumption, savings and tax payments. Row 1 represents the demand for commodities from the private sector and housing services, Row 3 represents household's allocation for savings and Row 4 comprises taxes on earnings. The household row represents the sources of income (land, labor and capital), government transfers including social security, and outside remittances. All other column and rows are interpreted in a similar manner.

The data must be organized in such a manner that it accomplishes two tasks. The first objective is to insure that the data can easily be updated or changed so that annual CGE models or a model for another town/city is easily constructed. The second objective is to link the SAM to the sources of the data such that the creation of the SAM is automatic and essentially self-balancing. To this end the data was stored in a series of worksheets that are linked to the SAM. Worksheets exist for each block in Figure 4.1. The advantage of using such a framework is that the SAM can be dynamically linked so as to make it self balancing except for some small sums in the Inter-Governmental transfer block. Data in the side worksheets are arranged in a uniform way across all cities in the study, which allows for relatively rapid SAM construction. Additionally, most of the proportionalization and transformation is done automatically, thus lightening the load on the modeler or principle investigator. This economy of human capital is one of the more attractive features of this data arrangement.

4.7 The side worksheets

Figure 4.2 presents the major linkages between the side worksheets and the SAM. These worksheets contain data for household expenditures, wages, I-O relationships, land

and capital components, the relationship between wage earners and the number of households (Synti) and the local government.

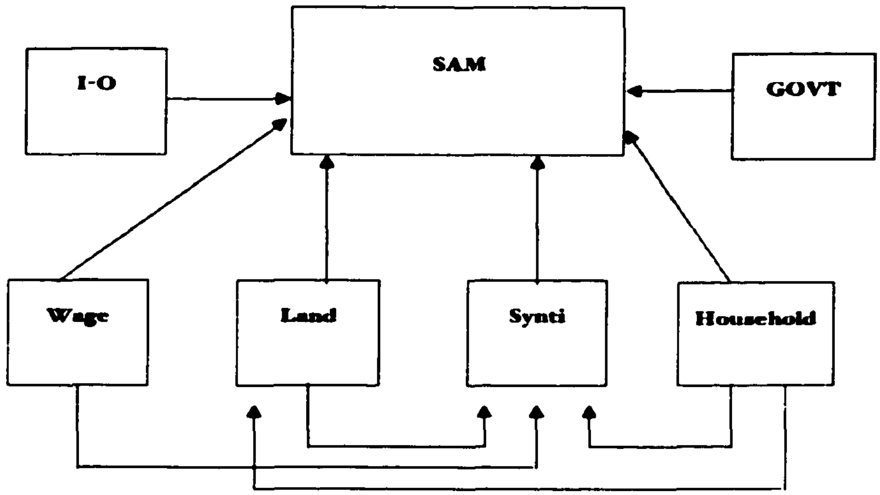

Figure 4.2: The Relationship of the Sidesheets to the SAM

Each worksheet contains a variety of the original input of the data. calculations and proportionalizations to insure that all the worksheets remain consistent with one another. The following sections further describe the major highlights of each worksheet and their connection to the SAM.

4.7.1 Households

This particular sheet has two primary functions: to establish and distribute residents to the household groups by income level, and to provide an accounting of expenditures. The number of households in a town is a crucial value for SAM construction and feeds into may different side worksheets. Census data combined with county business pattern data is reconciled with any other growth or distribution estimates to determine population and household composition. Additionally. the number of households is reconciled with the number of residential land parcels obtained from the land worksheet.

The sheet's second task is to determine the levels of household expenditures that are consistent with the distribution of households explained above. Data is initially imported from IMPLAN and adjusted with Consumer Expenditure Survey values, resulting in estimates of the level of household expenditures across all private sectors. Adjustments are made to ensure housing expenditures are consistent with all other household expenditures. It is further necessary to remove the value of mortgage payments from the finance and real estate sectors as those values are captured in the housing service payments entering from the land worksheet.

4.7.2 Wages

Wages can be separated into any number of groups desired (eight are utilized as described in Table 4.2) when they are drawn from the UI/ES202 data sets, and are inserted into this data sheet categorized by sector and income level. Once in the sheet, the social security paid by the employers is calculated along with that paid by the employees. This sheet serves as the primary entry point for not only the wages, but also the number of commuters in and out. The income flow from wages is modified by calculating and subtracting the wages leaving the city by way of workers commuting in, and adding back income that is earned by workers who commute out. Once adjustments to the incoming wages have been performed, the resulting values are transferred automatically to the Synti worksheet.

4.7.3 Land

The Land worksheet has several tasks to perform. The first of these is to determine the flow of income deriving from the land's property and structure stock values. To begin, the land and capital stock derived from county assessor's data file is inserted into the model. A depreciation rate of 10% is levied on the capital stock values. The same depreciation rate is also applied to the land stock remaining after maintenance, construction, and finance costs are accounted for. The resulting flow enters the SAM as part of factor demand in the productive sectors. This sheet is also responsible for distributing housing stock among the households derived from the household worksheet. In paticular, the number of households are reconciled with the number of residential parcels in the city. Parcels within the three Housing Services groups are apportioned across the six households groups according to income level. U.S. Census data provides a useful guide for this stage. Any remaining households are distributed among multiple-unit parcels. The ensuing matrix is linked to the household sheet, from which it enters the SAM. The housing sector is modeled as a productive sector similar to Pasha and Ghaus (1995) and Brueckner and Kim (2000).

4.7.4 The Synti

This worksheet is primarily responsible for assigning labor, land, and capital income to the resident households in each city. Labor income from the wage worksheet enters this sheet in eight income levels with non-resident commuters' (in-commuters) wages already subtracted out. Land and capital income derived in the land worksheet is also used in this worksheet. The core of this sheet is the relative comparison between the income and expenditures of the households. From the total value of expenditure, the capital income, private retirement and social security benefits are subtracted. The remaining expenditure per household group must be accounted for by labor income.

Logistically, the eight labor income categories are correlated to the six household categories by lower triangularizing a 6x8 matrix one column at a time, using the U.S. Census wage-earners per household values. In this way, not only is the income distributed, but also the number of workers per household group by income level determined. The resulting 6x8 "synti" is then linked to the respective block in the SAM (row 3, column 2 in Figure 4.1), although for this project, the 6x8 was horizontally summed to produce a 6x1 matrix as currently only one labor group is used in the model. A similar procedure is used to distribute the labor income of those workers who commute out-of-town. Since again, we have eight labor groups and six household targets, and thus generate another 6x8 lower triangular matrix.

4.7.5 I/O

The share proportions for each productive sector in the model are obtained from IMPLAN. These proportions are then parameterized, by subtracting the share proportions from the total proportional value (unity) leaving the proportion of value added. This amount is multiplied by the sectors' value added components (land, labor and capital) and taxes paid, which is automatically obtained from the SAM, to determine the total value in dollars, of the sector. The total amount, minus the dollar amount of value added must represent the dollar value of intermediate demand and is divided among the sectors according to the proportions in the IMPLAN I/O matrix. This final estimate of intermediate demand is then automatically inserted into the correct block in the SAM. Once set up, the only operation, which must be performed manually, is transferring the IMPLAN I/O into the worksheet, all other operations occur automatically.

4.7.6 Local Government

The local government provides services such as a police and fire and also imposes a variety of taxes on firms and households. Local taxes in sales, use, property and others are distributed over the private sector as well as the six household groups. In the SAM, Figure 4.1, these taxes appear in row 4 and columns 1 and 3. There are also federal and state taxes such social security and personal income taxes. Given the local focus of the model, these tax payments are not required to balance, and are free to flow out of the model.

The local government tax revenues are then distributed to pay for the following services: police, fire, transportation, library, administration, and parks & recreation. These expenditures are sub-divided into intermediate inputs, labor, land and capital. All of these values are automatically linked to the SAM.

4.8 Extensions

The data collection and organizational method described above has proven in practice to be both useful and to generate significant time savings. Not only were SAMs and CGE models generated for the aforementioned Fort Collins and Loveland, but also for 13 other towns and cities in both Larimer County and Weld County, Colorado. The data sources have proven to be reliable and consistent for each of the additionally modelled areas. Once the original methodology was established, continued production of regional city models was considerably improved through the use of these methods.

Chapter 5

The CGE Model

The analysis of the regional leadership problem uses a static, computable general equilibrium model loosely derived from the California DRAM of Berck et al. (1997) There are 17 productive sectors, three factors, four housing sectors, six household sectors, a state/federal government sector, and five local government sectors. Due to the importance of the region in this analysis, the model also includes local commuting and regional trade in addition to rest-of-world trade operating under the small open economy assumption. An extensive set of taxation and transfers is included, in addition to a labor migration function as part of the model. Model output includes a variety of potentially useful results, such as changes in gross city product, household income, exports, price level, and tax revenue.

5.1 Model Summary

This section provides a quick explanation of the key features for each equation block within the model.

5.1.1 Producer Behavior

The sub-model of producer behavior encompasses three agricultural sectors, construction, two manufacturing sectors, lodging, food service, finance and real-estate, wholesale, utilities, schools, universities, and both high and low service sectors. All production sectors use three primary factors: land, labor, and capital. Each sector produces a composite commodity that can be transformed into domestic supply and exports according to a constant elasticity of transformation (CET) function. Producers are assumed to maximize profits subject to their production technology, represented by a two-stage production function. The upper level is a Leontief combination of value-added and intermediate inputs. On the lower level. all primary factors are combined using a Cobb-Douglas (CD) function and. following Armington (1969), intermediate demand is represented as a composite of imported and domestic goods.

5.1.2 Household Behavior

Consumers are divided into 6 household groups depending on their income levels. In this economy. the representative consumer maximizes a utility function subject to a budget constraint, which equals the revenue of primary factors less income taxes on labor and with private and governmental transfers added. This income is allocated to private demand. housing demand. savings. and net transfer abroad. Utility maximization is modeled using a relative price constant elasticity of substitution (CES) function.

At both levels of the optimization process. the households determine the optimal quantities of the composite private goods which are. as intermediate inputs. imperfect substitutes of local and imported commodities. Using the dual approach allows one to get rid of the constant returns to scale problem on the production side and. on the consumption side. gives a true cost-of-living price index.

5.1.3 Government

The government is modelled in two levels, the state/federal level and the local level. The state and federal level collects income taxes including social security taxes. On the expenditure side, the state/federal level pays lump-sum transfers to the cities and households. and purchases inputs from the productive sectors. For the state/federal level. regional/town derived revenue does not have to equal expenditure.

The local government level generates revenue from property tax. sales tax and use tax. in addition to receiving lump-sum transfers from the federal/state level. The expenditure of this money is explicitly modelled with five local government sectors (Police, Transportation, Fire, Parks & Recreation, and Administration). These sectors hire labor and purchase from the productive sectors but are not profit maximizers. The local government level is, however, required to have a balanced budget.

5.1.4 Investment

Investment is modelled as an open flow in this model. A reasonable assumption as the imposition of local capital availability constraints is rather unrealistic. Certainly local conditions may impact the availability of investment; however, local savings is fundamentally unrelated to the available investment capital of the town or region.

5.1.5 Foreign Sector

The foreign sector is taken to be the rest of the world, outside the region in question. Thus, the town is treated as a relatively small and open economy with a preferred local trading parter (the other town) and the rest of the world. World prices are treated as exogenous variables. Again Armington (1969)'s approach is followed by assuming that imports are imperfect substitutes for similar domestic commodities. Both the domestic supply and exports of a commodity are a joint product of domestic production. In order to close the model, a trade balance is imposed with respect to the rest of the world, accounting for any surplus over trade with the preferred partner.

5.2 Computable General Equilibrium (CGE) Model

In a CGE model, the economy is fully specified in the sense that all producers face perfectly elastic demand for final goods in world markets and trade at exogenously given prices. There are three primary factors, labor (L), capital(K) and land(LA). Intermediate goods to be used for producing final goods form a secondary factor relationship as well. The level of these factors use is constant over time, mobile among sectors in the specified region.

and excepting capital, not freely mobile outside the region. Notation used in the equation descriptions below is further clarified and explained in Appendix A.

5.2.1 Producers

Unlike regional input-output and SAM models, which are solely based on Leontif technology, neoclassical theory guides the specification of production functions in CGE models. As a consequence, CGE models do not traditionally represent factor demand as linear function of output. Instead, factor demands usually depend on both output and relative prices (Vargas & Schreiner, 1999).

Producers comprise a large number of identically behaving firms, which, at the beginning of each year, rent primary inputs labor (L), a set of differentiated capital (K) from investment flows, and land (LA). Producers are assumed to maximize profit. Thus the fundamental behavioral assumption of the corporate sector is that firms strive to maximize the value of the outstanding stock of the shares. This results in each aggregate sector choosing the inputs (capital, labor, land), and intermediate goods that lead to the output that makes the most possible money. This choice is a function of the price of the output and the inputs. If dynamic producer behavior is introduced, production and investment are induced by either actual external costs or forgone output.

The production function used can summarized as:

$$q_i = \gamma_i \left[\sum_{f \in F} \alpha_i \left(u^d_{fi} \right)^{-\rho_i} \right]^{\frac{-1}{\rho_i}} \qquad \forall f \in F \tag{5.1}$$

Where γ_i is the production function scale, u^d_{fi} is sectoral factor demand, and ρ_i is the substitution exponent in the production function.

A Constant Elasticity of Substitution (CES) production function is used for each industry. In this, the employment of each factor (the set 'F', of which 'f' is one member: 'L' for labor and 'K' for Capital and 'LA' for land) is raised to an exponent and multiplied by a share parameter. The total of these products is raised to the inverse of the substitution exponent. The first parameter is the scale of production.

The current model has the elasticity parameters imposed from those found in published literature. In this study labor capital and land are substitutes in each industry. but not the perfect substitutes that would have been imposed had Cobb-Douglas production functions been employed.

This production function is constrained by the nonlinear inequality of zero profit. The zero profit inequality implies that in equilibrium no producer earns an "excess" profit. i.e the value of inputs per unit activity must be equal to or greater than the value of output. Following Perroni and Rutherford (1998) this can be written in compact form as:

$$\Pi_j(P) = C_j(P) - R_j(P) \geq 0$$

Where: Π_j is the unit profit function. the difference between unit revenue and unit cost. defined as:

$$C_j(P) = min\{P_i X_i; f(X) = 1\}$$

And

$$R_j(P) = max\{P_i Y_i; g(Y) = 1\}$$

Where f and g are the associated production functions characterizing feasible input and output. Thus the production function is constrained by the model closure equations. which serve the primary role of ensuring that these relationships hold.

Value Added Calculation

This equation takes the form:

$$p_i^{va} = p_i^d - \sum_{i' \in I} \alpha_{i'i} p_i \left(1 + \sum_{g \in GS} \tau_{gi'}^v\right) \tag{5.2}$$

where $\alpha_{i'i}$ are the domestic input-output coefficients , p_i^{va} is the value added price . p_i^d is the domestic producer price. p_i aggregate prices, and intermediate good sales and excise tax rates. $\tau_{gi'}^v$.

This equation and its left-hand side variable are calculating conveniences. The share of domestic price remaining for the payment of factors is calculated as the residual of selling price, less payments for intermediate goods—including sales/use taxes imposed on intermediates. This simplifies the form of the factor demand equations. Since intermediate goods are in fixed proportion to output, their shares of costs do not form a direct part of the profit maximizing use of various intermediates, *i.e.* there is no substitution between intermediate goods, nor between intermediates and factors. Prices begin at unity. The share parameters for intermediate goods and tax rates came from IMPLAN data.

5.2.2 Consumers

Households receive income from firms and buy products from either domestic or foreign firms. The CGE model incorporates the theoretical basis that the consumers' choice of goods is made within their budget constraint, with the income of consumers determined within the model. The solution to the consumer problem determines their demand curve for each marketed goods and their supply of labor.

Consumer Price Indices

Is represented by:

$$p_h = \frac{\sum\limits_{i \in I} p_i \left(1 + \sum\limits_{g \in GS} \tau^c_{gi}\right) c_{ih}}{\sum\limits_{i \in I} \bar{p}_i \left(1 + \sum\limits_{g \in GS} \tau^q_{gi}\right) c_{ih}} \tag{5.3}$$

where c_{ih} is household consumption, p_i is aggregate price, τ^c_{gi} are consumption sales and excise taxes, and τ^q_{gi} are sales and excise tax rates

Consumer price indices for each household type (the set 'H' of which 'h' is one member) are calculated against a reference period set at unity.

Household Gross Incomes

$$y_h = \sum_{f \in F} \frac{\alpha_{hf} a^w_h}{\sum\limits_{h \in H} \alpha_{hf} a^w_h} y_f \left(1 + \sum_{g \in GF} \tau^h_{gf}\right) \quad \forall h \in H \tag{5.4}$$

where y_h is household income, and y_f represents factor income which includes net commuting income and any outside land and capital income.

Household gross income is a function of payments to factors supplied by each household group and is apportioned to households on a fixed scale of shares α_{hf} per household type.

Household Disposable Incomes

$$y_h^d = y_h + \sum_{h \in H} y_h^m a_h^n + \sum_{g \in G} w_{hg} a_h^n - \sum_{g \in G} t_{gh} a_h - \sum_{g \in G} \tau_{gh}^h a_h \qquad \forall h \in H \tag{5.5}$$

Where y_h^d is household income after taxes, y_h is total household income, y_h^m is private retirement inflow, and w_{hg} represents transfer payments. Household disposable income is a function of gross household income left after all taxes have been paid and transfer payments received.

Private Consumption

$$c_{ih} = \bar{c}_{ih} \left(\frac{\bar{y}_h^d}{y_h^d} \div \frac{p_h}{\bar{p}_h} \right)^{\beta_{ih}} \prod_{i' \in I} \left[\frac{p_i \left(1 + \sum_{g \in GS} \tau_{gi}^c \right)}{\bar{p}_i \left(1 + \sum_{g \in GS} \tau_{gi}^q \right)} \right]^{\lambda_{i'i}} \tag{5.6}$$

Unitary income elasticities, zero cross price elasticities and unitary own price elasticities are imposed from published literature.

Household Savings

$$s_h = y_h^d - \sum_{i \in I} c_{ih} p_i \left(1 + \sum_{g \in GS} \tau_{gi}^c \right) \tag{5.7}$$

Where s_h is the quantity of household savings.

The simplest kind of savings function is presented: saving for each household type is the residual of disposable income less household expenditure. Thus, there is no 'motivation' for household savings. Some economists prefer to incorporate inter-temporal consumption preferences into a savings function. This may be appropriate for a national model, ignoring the effects of international capital flows, thereby establishing a condition in which savings constrain investment (and, implicitly, investment constrains savings), but it is unrealistic in a regional model. Investment in a city or region is in no way related to savings in that area. Thus, savings in a regional economy is a deadweight loss to that region. To minimize the impact of this deadweight loss, the 'savings as residual' functional form above was chosen.

5.2.3 Factor Demand

$$r_{fi} ra_f \left(1 + \sum_{g \in GF} \tau^x_{fig} \right) u^d_{fi} = p^{va}_i q_i \alpha_{fi} \qquad \forall f \in F,\ i \in I \tag{5.8}$$

Where r_{fi} are sectoral factor rental shares, ra_f represents an economy-wide scalar for factor rental rates, u^d_{fi} is factor demand, and q_i represents domestic supply

Factor demand functions are calculated by taking the first derivative of the profit function with respect to each factor demand variable, holding prices and other factor demands constant. The expression in the left hand side brackets generates the taxes on factors used in production. Taxes on labor represent employer portions of Social Security, Unemployment Insurance, Workers Compensation and similar taxes. Taxes on capital represent corporate income and franchise taxes. The right hand side represents the marginal benefit of a unit factor, including the value added net revenue plus investment tax credits earned.

The sectoral wage differential is calculated for labor from wage payments and employment data from ES-202 and UI sources. For labor, the inter-sectoral differences, r_{fi}, were fixed and the economy-wide variable was allowed to vary. The situation is reversed for capital and land. From published literature, initial rates of return by sector were established and the economy-wide variable was fixed at unity.

Intermediate Demand

Is characterized by:

$$v_i = \sum_{i' \in I} \alpha_{ii'} q_{i'} \tag{5.9}$$

where v_i represents the value of intermediate goods.

In all industries, intermediate goods are in fixed shares of production. This provides for a major simplification and size reduction to the model: intermediate demand is not calculated as a separate variable for each industry supplying each other industry, but only as a total demand for intermediates from each industry. This is the sum of shares of production from each other industry and from itself. Share data was derived from the IMPLAN input-output tables, with additional parameter estimates subsequently applied.

Factor Income

$$y_f = \sum_{i \in IG} r_{fi}\, ra_i\, u^d_{fi} \tag{5.10}$$

This is a simple calculation device to gather all payments to factors from sectors and from governments.

5.2.4 The Government

The government is exogenous to the model. It chooses a set of policies to allocate available funds among specified number of priorities.

Government Income

$$\begin{aligned} y_g = & \sum_{i \in I} \tau^x_{qgi} v_i p_i + \sum_{i \in I} t^x_g e_i p^d_i + \sum_{i \in I} \tau^m_{gi} m_i p^w_i + \sum_{i \in I} \sum_{h \in H} \tau^x_{qgi} c_{ih} p_i + \sum_{i \in I} \tau^x_{qgi} c_{in} p_i \\ & + \sum_{i \in I} \sum_{g' \in G} \tau^x_{qgi} c_{ig'} p_i + \sum_{i \in I} \sum_{f \in F} \tau^x_{gi} r_{fi} ra_f u^d_{fi} + \sum_{g' \in G} \sum_{f \in F} \tau^x_{gi} r_{fg} ra_f u^d_{fg'} \qquad (5.11) \\ & + \sum_{f \in F} \tau^h_f y_f + \sum_{h \in H} \tau^h_{hg} a_h + \sum_{h \in H} t_{gh} a^w_h + \sum_{g \in GX} b_{gg} \qquad \forall g \in G \end{aligned}$$

Government income is the sum of sales taxes collected from domestic consumption (intermediates, exports, imports, household consumption, investment and governments), plus taxes on factor payments, plus taxes collected from households (income taxes and per household taxes), plus inter-governmental transfers. All tax rates were derived from careful analysis of federal, state and local financial publications.

Government Endogenous Purchases of Goods and Services

$$p_i \left(1 + \sum_{g \in GS} \tau_{gi}^{g} \right) c_{ig} = \alpha_{ig} \left(y_g + \sum_{g' \in G} b_{gg'} - \sum_{g' \in G} b_{g'g} \right) \quad \forall i \in I,\ g \in GN \tag{5.12}$$

Shares of nominal endogenous government spending calculated from existing budgets and financial reports form the basis of these equations. Nominal spending, including taxes paid for goods and services form the left-hand side. The shares are applied to the net receipts of these units: tax revenues, plus inter-governmental transfers in, less inter-governmental transfers out.

Government Endogenous Rental of Factors

$$u_{fg}^{d} ra_f r_{fg} = \alpha_{ig} \left(y_g + \sum_{g' \in G} b_{gg'} - \sum_{g' \in G} b_{g'g} \right) \quad \forall i \in I,\ g \in GN \tag{5.13}$$

Parallel with the equations immediately preceding, shares of government spending for factor rentals are applied to government incomes (right-hand side) and set equal to nominal government factor rentals. Government factor taxes paid to other governments do not appear as these were omitted from the share calculations.

Government Savings

$$\begin{aligned} s_g = y_g - \sum_{i\in I} c_{ig} p_i \left(1 + \sum_{g\in GS} \tau^g_{gi}\right) - \sum_{f\in F} u^d_{fg} r_{fg} ra_f \left(1 + \sum_{g'\in GF} \tau^x_{fg'i}\right) \\ - \sum_{h\in H} w_{hg} a^n_{hg} - \sum_{g'\in G} b_{g'g} + \sum_{g'\in G} b_{gg'} \qquad \forall g \in G \end{aligned} \tag{5.14}$$

As with the household savings function, government saving becomes the residual from government income less government purchases of goods and services less government rental of factors less government welfare payments less net intergovernmental transfers paid. While combined here, the equation is in two parts in the GAMS code.

Household Taxes

Households pay income, sales and property taxes to three levels of government. Sales taxes are embodied in the prices they face in markets and are collected by firms and are determined elsewhere in the model. Direct taxes, per household, (income and property) are a function household incomes. These totals are corrected to reflect actual tax collection within each town/city or region.

5.2.5 The Foreign Sector

Agents outside the modeled region are labeled foreign, even though they would include agents outside the city or region in addition to U.S. states and other countries. In this model, foreign agents are taken as having a known demand curve for each good and service. Net demand is a device that captures exports and imports in the same equation.

Export Demand

$$e_i = \bar{e}_i \left[\left(p^d_i \sum_{g\in GK} 1 + \tau^x_{gi} \right) \Big/ \left(\bar{p}_i{}^w \sum_{g\in GK} 1 + \tau^q_{gi} \right) \right]^{\eta^e_i} \tag{5.15}$$

Export demand for domestic production is a simple function of observed exports and the relationship between domestic and world prices, including taxes. As domestic prices rise in relation to world prices, exports fall. However, they do not drop to zero the instant that domestic prices rise beyond world ones. This represents a functional form different from some CGE models, which have domestic producers not being able to adjust easily between domestic production for domestic consumption and domestic production for foreign consumption. This type of function would be more appropriate for a developing economy which produces a good for domestic consumption not fit for export customers. It would appear inappropriate to model a developed region much less a city as such an economy. Current exports were initially drawn from IMPLAN data. However, as the integrity of these data became suspect and as there appeared to be no consensus in the published literature, moderate elasticities for highly traded industries and low elasticities for less-traded ones were used.

Domestic Shares

$$d_i = \bar{d}_i \left[p_i^d \div \bar{p}_i^w \div \left(1 + \sum_{g \in G} \tau_{gi}^m \right) \right]^{\eta_i^d} \tag{5.16}$$

The domestic share of domestic consumption adjusts in ways similar to that of exports, with the relationship to relative prices. Many CGE modelers use a constant elasticity of substitution function for import demand (the so-called Armington assumption). Here the first order conditional, utility maximization form is used. Imports and domestic production are not perfect substitutes in the minds of consumers, firms, governments and investors. Imports taken from IMPLAN data. As with exports, this data was ruled suspect and moderate elasticities for highly traded industries and lower elasticities for less-traded ones, were imposed.

Import Demand

$$m_i = (1 - d_i)\,x_i \tag{5.17}$$

Imports, given the domestic share function above, are simply the share of domestic consumption that is not supplied by domestic sources. The shares are determined in the preceding equations.

Aggregated Prices

$$p_i = d_i p_i^d + (1 - d_i)\,\bar{p}_i^w \left(1 + \sum_{g \in G} \tau_{gi}^m\right) \tag{5.18}$$

Average prices faced by domestic households for goods and by firms for intermediate goods are calculated by multiplying the domestic share times the domestic price and adding this to the import share (one minus the domestic share) times the world price. The world prices are augmented by import duty paid to various levels of government services. There is one of these equations for each industry (the set 'I', of which 'i' is one member). All prices (domestic and foreign) are in relation to current ones, *i.e.* are set to unity prior to solving the model—although the world prices are adjusted by import duties. See the trade section above for a discussion of the domestic ratio.

Net Capital Inflow

$$\begin{aligned} z = \sum_{i \in I} m_i \bar{p}_i - \sum_{i \in I} e_i p_i^d - \sum_{h \in H} y_h^m a_h^n - \sum_{f \in F} y_f^m \\ - \sum_{l \in L} Exwage_l * \overline{CMO}_l - \sum_{l \in L} -r_l * \overline{CMI}_l \end{aligned} \tag{5.19}$$

To keep track of capital flows, the net of outflows (imports less exports) is set to equal inflows. This is a standard feature of CGE models that take explicit account of the circular flow in the economy. This highlights an important feature of a regional economy, as opposed to a national economy. Investment is not bounded by local savings. Capital inflows passively adjust to the demands of the local economy.

5.2.6 Investment

Gross Investment by Sector of Destination

$$n_i^k = \bar{n}_i^k \left(\frac{r_{K,i}}{\bar{r}_{K,i}}\right)^{\eta_i^k} * \left(\frac{u_i^d}{\bar{u}_i^d}\right)^{\eta_i^k} \tag{5.20}$$

Investment decisions are made sector-by-sector depending on changes in the return to capital in each sector and the relative demand in each sector. A similar equation is used for investment in the government sectors. however relative funding changes are used instead of demand to apportion investment between G sectors.

Sectoral investment data are not included in IMPLAN for investment by destination. Using the typical CGE assumption that the economy begins in equilibrium. payments to capital were assumed to be reflective of maintenance of existing capital. using a 10% depreciation rate. Applying this to rates of return. capital stocks were established by sector and the depreciation rate applied to develop the initial gross investment by sector of destination data.

Gross Investment by Sector of Source

$$p_i \left(1 + \sum_{g \in GS} \tau_{gi}^n\right) c_i^n = \sum_{j \in I} \sum_{k \in K} \beta_{ij} \; n_i^k \tag{5.21}$$

Investment demand for each sector's output is a fixed share of observed investment demand from all other sectors that invest. using the shares, by type of capital. from the capital coefficient matrix. If one assumes that the shares (by source) of investment do not change significantly, there is no need in the model to track investment demand with variables for each source-destination combination.

5.2.7 Capital Stock

$$u^s_{K,i} = \bar{u}^s_{K,i}\,(1 - \delta_i) + n^k_i \tag{5.22}$$

Capital stock is depreciated current capital stock, plus gross investment. Current sectoral capital stocks were imposed by imposing sector-specific returns to capital derived from published literature and dividing payments from each sector to capital by these rates of return.

5.2.8 Factors

Labor Supply

$$\frac{a^w_h}{a_h} = \frac{\bar{a}^w_h}{\bar{a}_h}\left[\left[\left(\frac{\sum_L \left(\frac{r^a_l}{\bar{r}^a_l}\right)}{\left(\frac{p_h}{\bar{p}_h}\right)}\right)\left(\frac{\sum_{Z,L} u^d_{z,l}}{\left(\sum_H a^w_h * \epsilon\right) + CMI}\right) + \left(\sum_L \frac{Exwage_l}{r^a_l}\right)\left(\frac{CMO}{\left(\sum_H a^w_h * \epsilon\right) + CMI}\right)\right]^{\eta^{LS}_h} \left(\frac{\sum_{g\in G} \frac{w_{h'g}}{p_h}}{\sum_{g\in G} \frac{\bar{w}_{h'g}}{\bar{p}_h}}\right)^{\eta^w_h}\right] \tag{5.23}$$

Labor supply is expressed in terms of the participation rate: the number of working households (a^w_h) divided by the number of households in an earnings class (a_h). This is a function of the initial participation rate ($\bar{a}$) modified by four factors: change in the economy-wide wage rates(r^a_L), the change in household earnings both from in town and commuting sources ($(a^w_h * \epsilon) + CMI$), change in the proportion of factor demand ($u^d_{z,l}$) satisfied by commuting in, and the change in that household's average transfer payments when not working($w_{h'g}$). We assume that each household responds with a constant set of elasticities(η^{Ld}_h, η^W_h), but vary these elasticities across households. For example, high income households have higher elasticities with respect to wages and taxes than low income households, but high income households have no responsiveness to transfer payments. Low income households have lower elasticities with respect to wages and taxes and higher responsiveness to transfer payments.

5.2.9 Migration

$$a_h = \bar{a}_h \pi + \bar{a}_h^{in} \left(\frac{\bar{a}_h\, p_h\, y_h^d}{a_h\, \bar{p}_h\, \bar{y}_h^d} \right)^{\eta_h^{yd}} \left(\frac{a_h^n\, \bar{a}_h}{a_h\, \bar{a}_h^n} \right)^{\eta_h^u} - \bar{a}_h^{out} \left(\frac{a_h\, \bar{p}_h\, \bar{y}_h^d}{\bar{a}_h\, p_h\, y_h^d} \right)^{\eta_h^{yd}} \left(\frac{a_h\, \bar{a}_h^n}{a_h^n\, \bar{a}_h} \right)^{\eta_h^u} \quad \forall\, h \in H \tag{5.24}$$

The population for each household type is a function of existing population. increased by the natural rate π and by the effect of net migration. which depends upon after tax incomes (y_h^d) and that household's fraction of non-working members. Working population depends on the after-tax return to labor. Total population is a function of the changing attractiveness of the city or town. as measured by real after-tax earnings changes and employment prospects. Population figures were imposed at this stage of development. Given the functional forms of the equations involving population. the change in population becomes more important than the actual levels. Elasticities assigned reflect a middle ground between those found in the literature about migration. Higher income households are more prone to being attracted by high after tax wages and lower income homes focus more on employment prospects.

5.2.10 Commuting

$$CMO = \overline{CMO} \left(\frac{Exwage_L}{ra_L} \right)^{\eta_{como}^L} \tag{5.25}$$

$$CMI = \overline{CMI} \left(\frac{ra_L}{Exwage_L} \right)^{\eta_{comi}^L} \tag{5.26}$$

These equations identify commuting out and in respectively.

Commuting out, 5.25, is a function of the base value CMO_o and the external wage ($Exwage_L$) relative to the internal return on labor (ra_L). The commuting in equation. 5.26. is set up in a similar fashion. Changes in commuting are a result of the greater or lesser wage attractiveness of each individual town versus the rest of the world. Prices of goods between cities or areas do not appear in these equations since the location decision has already been made by the household in equation 5.24. When both equations are considered, households make a residential locational choice when they enter the region, followed by a working location choice. Elasticities were chosen to ensure that commuting changes occur prior to, or more easily than migratory changes.

Number of Non-working Households

$$a_h^n = a_h - a_h^w \tag{5.27}$$

The number of non-working households, per household group, is simply the count of that household's population, less those with jobs.

5.3 CGE Model Assumptions and Closure

Kazarian (1997) provides an excellent description of CGE model structure and an exhaustive description of CGE model assumptions, however, only some of them apply to this model. Those assumptions that do are: Markets clear, agents behave optimally, functional representations of consumer preferences and producer technology is feasible, technologies are constant return to scale, no excess demand exists for any good, every producer earns zero profit, no consumer exceeds their budget, preferences are identical and homothetic, the utility function is additively separable, and the number of time periods is finite

5.3.1 Model Closure

State Personal Income

$$q = \sum_{h \in H} y_h + \sum_{h \in H} \sum_{g \in G} w_{hg} a_h^n + \sum_{h \in H} y_h^m a_h^n \tag{5.28}$$

Personal income is the sum of 'earned' income (payments from rental of factors by households) and transfer payments, both from the government and private retirement. There are several reasons this variable is included: First, personal income is a figure of interest to economists analyzing regional economies and changes to its value form an integral part of analyzing the effects of institutional or policy change. Second, since the mathematical programming software (GAMS) incorporates non-linear optimization rather than a simultaneous equation solution, a variable unrestricted in value and without a subscript was required.

Labor Market Clearing

$$\sum_{h \in H} (a_h^w * \varepsilon) + CMI_L = \sum_{i \in I} u_{Li}^d + CMO_L \tag{5.29}$$

An important feature of CGE models is that factor markets clear. The interrelationship between household decisions to supply labor (depending on the real return to work) and those of firms to demand labor (depending on the profit maximization decision) is critical to CGE models. The parameter ε, referred to as 'JOBCOR' in Section 4.3, when applied to the number of jobs scales households (left-hand side) to jobs. Commuting is handled differently as it is already in per worker units, not households.

Capital Market Clearing

$$u_{K,i}^s = u_{K,i}^d \tag{5.30}$$

As with labor, capital markets clear, sector-by-sector.

Domestic Demand

$$x_i = v_i + \sum_{h \in H} c_{ih} + \sum_{g \in G} c_{ig} + c_i^n \tag{5.31}$$

This equation demonstrates one of the most critical clearing assumptions. The model is forced to balance domestic production with demand for this production (domestic plus foreign demand, less imports).

Goods Market Clearing

$$q_i = x_i + e_i - m_i \tag{5.32}$$

Domestic demand is defined as the sum of intermediate, consumer, government and investment demand (5.31). Domestic supply must meet this amount for the goods markets to clear. This function could have been incorporated into the equation above and into the trade demand equations, but has been kept separate for simplicity and transparency reasons.

As mentioned above, there are several differing or competing schools of thought concerning the closure rules for a CGE. Although it is not specified in the closure equations, the models structure does incorporate unemployment in equation 5.23, households can choose not to work. Thus, while many of the closure rules might be considered "Neoclassical" in nature, the model itself, with the incorporation of unemployment and savings $\neq$ investment, has elements normally associated with "Keynesian" closure rules. Therefore, it seems reasonable to argue that this study adopts a relatively "middle of the road" position concerning model closure.

5.3.2 Elasticities and Sensitivity

The differences in key elasticities between Fort Collins and Loveland is examined in this section. For the most part both cities share similar values. In particular, the households, as seen in Tables 5.1 and 5.2, share identical middle of the road values for Labor responsiveness to the average wage, Labor responsiveness to income taxes, Household employment decision, and Household response to taxes and the value of transfer payments.

When examining the production side of the model, there are some differences reflecting the contrasting nature of the two towns. However for the most part the elasticities imposed are similar. Tables 5.3 and 5.4 display the productive sectors by the key elasticities. These key elasticities include: Beta, the income elasticity of demand; Lambda the cross (own) price elasticities; Rho, the production function exponent; Land(etal), the land supply elasticity;

Labor(etalb), the labor supply elasticity; Capital(etai), the investment supply(capital) elasticity; and export(etae), the export elasticities with respect to domestic price. As can be seen, differences are primarily centered in the Rho and export columns, two elasticities most likely to need variation between towns.

Table 5.1: Fort Collins Household Elasticities

	Labor/Avg Wage	Labor/Taxes	Unemployment	Tax	Transfers
HH1	1	1	-1	0	-0.05
HH2	1	1	-1	-0.15	0
HH3	1	1	-1	-0.20	0
HH4	1	1	-1	-0.25	0
HH5	1	1	-1	-0.35	0
HH6	1	1	-1	-0.40	0

Table 5.2: Loveland Household Elasticities

	Labor/Avg Wage	Labor/Taxes	Unemployment	Tax	Transfers
HH1	1	1	-1	0	-0.05
HH2	1	1	-1	-0.15	0
HH3	1	1	-1	-0.20	0
HH4	1	1	-1	-0.25	0
HH5	1	1	-1	-0.35	0
HH6	1	1	-1	-0.40	0

In addition to the established elasticities presented, several key equations have modifiers attached to their elasticities to control the inelastic/elastic properties of the entire market, across all included sectors without changing individual interrelationships. For Fort Collins the elasticity modifications within the equations used for this study are as follows:

$$LASEQ1(LA,I)..LAS(LA,I) = E =$$
$$LAS0(LA,I)(*) * *(ETAL(LA,I) * 2.5)(*) * *(ETAL(LA,I) * .77)$$

$$NEQ1(K,I)..N(K,I) = E =$$
$$N0(K,I) * (*) * *ETAIX(K,I) * (*) * *(ETAIX(K,I) * 1.1)$$

$$LSEQ1(H)..HW(H)/HH(H) = E =$$
$$HW0(H)/HH0(H) * (*) * *((ETARA(H)) * 3.0)$$

For Loveland the elasticity modifications within the equations used for this study are as follows:

$$LASEQ1(LA,I)..LAS(LA,I) = E =$$
$$LAS0(LA,I)(*) * *(ETAL(LA,I) * 1.6)(*) * *(ETAL(LA,I) * 1.01)$$

$$NEQ1(K,I)..N(K,I) = E =$$
$$N0(K,I) * (*) * *ETAIX(K,I) * (*) * *(ETAIX(K,I) * 1.1)$$

$$LSEQ1(H)..HW(H)/HH(H) = E =$$
$$HW0(H)/HH0(H) * (*) * *((ETARA(H)) * 2.0)$$

Finally, both commuting-in and commuting-out have elasticities, for both towns they are the same: 1.0 for commuting-in, and 5.0 for commuting-out.

Table 5.3: Fort Collins Production Elasticities

	Beta	Lambda	Rho	Land	Labor	Capital	Export
AGPRO	1	-1	0.9	0.5	1	1	-3.65
AGSER	1	-1	0.9	1	1	2	-3.65
CONST	1	-1	0.6	1.4	1	2	-3.65
MINNG	1	-1	0.6	1	1	2	-3.65
AGPRS	1	-1	0.6	1	1	1	-3.65
MANUF	1	-1	0.6	1	1	2	-3.65
CMANF	1	-1	0.6	1	1	2	-3.65
COMMU	1	-1	0.6	1	1	2	-3.65
ELECT	1	-1	0.6	2	1	2	-3.65
WATER	1	-1	0.6	2	1	2	-3.65
RETAL	1	-1	0.6	1.5	1	3	-3.65
FIRE	1	-1	0.6	2.5	1	3	-3.65
LODGE	1	-1	0.6	2	1	3	-3.65
EATING	1	-1	0.6	2	1	3	-3.65
LWSER	1	-1	0.6	0.7	1	3	-3.65
HGSER	1	-1	0.6	1.5	1	3	-3.65
TRUTL	1	-1	0.6	2	1	2	-3.65
WHOLE	1	-1	0.6	1	1	2	-3.65
ELE2	1	-1	0.6	1.5	1	2	-2.65
UNIJC	1	-1	0.6	0.8	1	2	-3.65
HS1	1	-1	0.6	2.5	1	2	0
HS2	1	-1	0.6	2.5	1	2	0
HS3	1	-1	0.6	2.5	1	2	0
HS4	1	-1	0.6	2.5	1	2	0
STFED	0	0	0	1.5	1	1	0
CYPOL	0	0	0	2	1	1	0
CYTRA	0	0	0	2	1	1	0
CYLPR	0	0	0	2	1	1	0
CYFIR	0	0	0	2	1	1	0
CYADM	0	0	0	2	1	1	0

Table 5.4: Loveland Production Elasticities

	Beta	Lambda	Rho	Land	Labor	Capital	Export
AGPRO	1	-1	0.9	2	1	2	-3.65
AGSER	1	-1	0.9	2	1	2	-3.65
CONST	1	-1	0.6	1	1	2	-3.65
MINNG	1	-1	0.6	2	1	2	-3.65
AGPRS	1	-1	0.6	2	1	2	-3.65
MANUF	1	-1	0.6	2	1	2	-3.65
CMANF	1	-1	0.6	2	1	2	-3.65
COMMU	1	-1	0.6	2	1	2	-3.65
ELECT	1	-1	0.6	2	1	2	-3.65
WATER	1	-1	0.6	2	1	2	-3.65
RETAL	1	-1	0.6	1.5	1	3	-0.65
FIRE	1	-1	0.6	2	1	3	-3.65
LODGE	1	-1	0.6	1.1	1	3	-0.65
EATING	1	-1	0.6	1.7	1	3	-0.65
LWSER	1	-1	0.6	1	1	3	-3.65
HGSER	1	-1	0.6	1	1	3	-3.65
TRUTL	1	-1	0.6	2	1	2	-3.65
WHOLE	1	-1	0.6	1	1	2	-3.65
ELE2	1	0	0.6	2	1	2	-2.65
UNIJC	1	0	0.6	2	1	2	-3.65
HS1	1	-1	0.6	3	1	2	0
HS2	1	-1	0.6	3.5	1	2	0
HS3	1	-1	0.6	3	1	2	0
HS4	1	-1	0.6	3	1	2	0
STFED	0	0	0	2	1	1	0
CYPOL	0	0	0	2	1	1	0
CYTRA	0	0	0	2	1	1	0
CYLPR	0	0	0	2	1	1	0
CYFIR	0	0	0	2	1	1	0
CYADM	0	0	0	2	1	1	0

Chapter 6

Model Results

The results from two separate simulations will be presented in this chapter. The first simulation presents results that underscore the fundamental differences obtainable by the model for two different municipalities. The second simulation follows the game theoretic presented above. Not only do these simulations present evidence for treating regional issues co-operatively, they illustrate the flexibility and sophistication of the issues that the above constructed model may be used to analyze.

6.1 Simulation: Degree of Model Sensitivity

Recalling Table 4.1, two different cities or towns in northern Colorado are examined in this section. The largest municipality is Fort Collins, which has a population of approximately 100,000 people and is the primary employment center for the region. The second city is Loveland, which has a population of approximately 50,000 people.

The economic impact of a 250 employee manufacturing firm moving into each of the two towns is examined. This is the standard size of a typical manufacturing firm that might consider locating in this region. Each municipality is estimated separately, but there are linkages due to commuting and purchases across each area. The simulation is accomplished by increasing the value of exports in the manufacturing sector. This value is increased until employment in manufacturing increases by 250 workers. As wages change in each town, the number of workers and households in each town change as described by equations 5.23 – 5.26.

The simulations were set up as follows: The base value of exports (CX0) for the sector in question was altered, which has initial effect on Equation 5.15. This base value of exports (CX0) in the manufacturing sector was increased by the amounts in Table 6.1 for each town respectively. Since 250 workers is a far more substantial increase in Loveland compared to Fort Collins, an attempt was made to correct for the relative size of the firm by also simulating an equivalent size firm entry. For Fort Collins 250 new workers is a .39% increase in employment, therefore the equivalent size firm in Loveland is 98 workers. To aid in direct comparison the values obtained from the equivalent simulations were scaled upwards by 2.55 or $\frac{250}{98}$, these values are reported as Loveland (Scaled) in the results tables.

Table 6.1: Values Altered for Simulation

City	Percent Increase in CX0
Fort Collins	5.8
Loveland	7.9
Loveland, Eqv. Size	2.9

Given the above changes, the models were re-estimated. Table 6.2 presents the employment multipliers for each of the cities/towns. The multipliers for Fort Collins, Loveland and Loveland (Eqv.) are 1.54, 1.23 and 1.14 respectively. The differences in the estimated multipliers are consistent with the varying economic structures of the two municipalities. Loveland is a smaller community with less developed retail and service sectors. More jobs will translate into greater expenditures in Loveland, but since a proportion of those household expenditures are made in Fort Collins, the indirect effects will be smaller. The employment multiplier for Fort Collins is slightly larger than for Loveland, due to the fact that Fort Collins residents can purchase a larger percentage of goods and services within-town. In short, it is true that any expansion will fuel greater local economic activity. However, it is also the case that Loveland residents still have to make relatively more purchases outside of town than Fort Collins residents, which results in a smaller employment multiplier for Loveland.

Table 6.2: Employment Multipliers

City	Base Value of Employment	Change in Employment	Percentage Change	Employment Multiplier
Fort Collins	64,281	385	0.60%	1.54
Loveland	25,441	308	1.21%	1.23
Love., Eqv.	25,441	112	0.44%	1.14
Love., Scale	25,441	286	1.12%	1.14

The increase in employment opportunities across these two municipalities will impact the number of new households entering these areas, as well as commuting patterns in the region. The increase in the supply of workers derives from either households moving into the town (equation 5.24) or a change in commuting patterns (equations 5.25 and 5.26). The number of households entering a town or city depends on changes in household income and prices as depicted in equation 5.24. The primary factors influencing household income are the income derived from land, labor and capital. Commuting patterns are only influenced by changes in labor income. Given that the levels of household income and labor income differ across the two municipalities, we should expect to see different impacts on the number of households and commuters responding to the expansion in employment opportunities in manufacturing.

Table 6.3 presents the changes in the number of households entering each town and Table 6.4 presents the change in commuting patterns. With respect to Fort Collins, most of the increase in the supply of workers results from 194 households moving into town. This is in stark contrast to Loveland where new households only increase by 14. This difference is partially a result of household income increasing by 1.64% in Fort Collins but only 1.05% in Loveland. The larger increase in household income in Fort Collins is due to increases in land and capital income. Simulation results indicate land and capital income have increased almost five-fold over Loveland. This is a direct result of more restricted land availability in Fort Collins, compared to Loveland.

Table 6.3: Impact on Households

Changes in:	Base Number of Households	Change in Households	Percentage Change
Fort Collins	40,119	194	0.48%
Loveland	16,886	14	0.08%
Loveland, Eqv.	16,886	12	0.07%
Loveland, Scale	16,886	30	0.17%

In addition, Table 6.4 indicates that there is a decrease in commuting out by only 18 workers and only 5 additional workers commute into Fort Collins. Since wages only increase by 0.03% in Fort Collins, the impact on commuting is minimal. The increase in wages for Fort Collins is likely to be smaller since a 250-worker increase in employment in manufacturing is relatively insignificant compared to the total employment of 64,281. However for Loveland, wages increase by 0.4%, which results in 247 workers now choosing not to commute out but to find employment in Loveland, while an additional 42 workers choose to commute into Loveland.

The combination of relatively small changes in household income and a relatively large increase in wage rates for Loveland results in changing commuting patterns satisfying the increased demand for labor. For Fort Collins, it is the exact opposite, as relative price changes cause the increased demand for labor to be primarily satisfied by households moving into the city.

Table 6.4: Impact on Commuting

Changes in:	Change in Commuting In	Percentage Change	Change in Commuting Out	Percentage Change
Fort Collins	5	0.03%	-18	-0.12%
Loveland	42	0.35%	-247	-1.73%
Love., Eqv.	13	0.11%	-78	-0.35%
Love., Scale	33	0.27%	-199	-1.39%

The response to the manufacturing firm moving into either town, yields very different zoning issues for the two towns. Fort Collins will have to zone land to accommodate 194 families moving into town while Loveland only has to zone land for 14 new families. Not only will Fort Collins have to zone for more residential land, but there will likely be increased demand for city services such as police, fire, and wastewater, further increasing the relative cost of the growth. Once again Loveland, with fewer new residents and less commuting out will have appreciably fewer indirect costs arising from the new manufacturing plant.

Next the impact of the new manufacturing firm on Gross City Product (CGP) in Table 6.5 is considered. It is not surprising that GCP increases by a greater absolute amount for Fort Collins than Loveland. The absolute increase in GCP for Loveland is \$8.19 million vs. \$12.26 million for Fort Collins. The greater employment impact in Fort Collins generates larger indirect impacts and therefore, a larger increase in GCP. However this is only a part of the story. Fort Collins' GCP only grew by .53% compared to Loveland's 1.2% increase. This

Table 6.5: Gross City Product Impacts

City	Base Value of GCP (mil \$)	Change in GCP(mil \$)	Percentage Change	Sales Tax Revenue Change	Revenue Change %
Fort Collins	2,331.7	12.26	0.53%	\$84.626	0.37%
Loveland	682.3	8.19	1.20%	\$82,422	0.76%
Love., Eqv.	682.3	2.94	0.43%	\$32.122	0.26%
Love., Scale	682.3	7.49	1.10%	\$81,911	0.66%

greater percentage increase in Loveland compared to Fort Collins. may result from Loveland being on a steeper part of the production function, relative to Fort Collins.

More interesting perhaps is the sales tax situation. From an absolute perspective. Fort Collins experiences slightly less than twice the GCP growth than Loveland. However. Loveland experiences approximately the same increase in sales tax growth. This result continues to be observed even in the scaled values, indicating its persuasive effect. To further understand this issue prices and quantity changes in selected sales tax paying sectors were examined for each town. These results are presented in Table 6.6.

Table 6.6: Changes in Prices, Domestic Demand & Average Wage

Variable	Sector	Fort Collins	Loveland	Loveland. Eqv	Loveland. Scale
P	Retail	.000075	.0022	.00089	n.a.
	Eating	.0034	.00085	.000343	n.a.
	Lodge	.000002	.000001	.000001	n.a.
DD	Retail	.53	.65	.27	.68
	Eating	.345	.40	.16	.40
	Lodge	.311	.594	.232	.591
RA		1.00031	1.0035	1.00138	1.0035

With this information. the situation becomes clearer. Loveland experiences such a high level of sales tax increase. largely due to increases in the price level. In all but one case the increase in Loveland's prices is considerably larger than Fort Collins. The sales tax gains are further aided by the considerable increase in domestic demand in Loveland. despite the increase in prices. This increase in demand can be attributed to the large increase in average wages in Loveland. more than 10 times that of Fort Collins. Ultimately. this revenue growth provides the city with greater budgetary discretion. relative to Fort Collins. which must spend most. if not all of its revenue on city services for its new residents. Thus. one might conclude that Loveland is the better location for the manufacturing plant given its gains relative to the other town.

6.1.1 Discussion

The above simulations demonstrate the uniqueness of the results obtainable with the modeling techniques presented in this study. They highlight the fact that fundamental differences exist between towns and that those differences are directly a function of the towns themselves. not the model. as it remained unchanged. Not only are the results presented interesting by themselves. but the differences obtained demonstrate the suitability of the model to examine the results of the game theoretic presented in Chapter Three.

6.2 Simulation: Game-Theoretic Results

For this section, once again models of Fort Collins and Loveland, Colorado were used as a basis for the simulations. Both towns are reasonably close in their economic development stage and have a similar mix of housing and industry, while Fort Collins is about 45% larger. The choice of cities was dictated by two factors, availability of data and relative similarity. To isolate the effect of differing town government, land zoning, or taxation policies, it was important to minimize the stray effects of truely different developmental stages and city composition. While the size difference is not ideal, it is more favorable than alternative city choices. Since the theoretical analysis largely concerns the government and its responses, it is natural to use a related measure. Therefore, for this section, city tax revenue was selected and analyzed as the primary simulation result.

For the purpose of providing an economic stimulus to the towns, a new 200 worker general manufacturing plant was introduced into the model region. There are two direct effects or considerations which arise: where to put the plant and where will the workers live. Plant location is pre-determined by whichever game-theoretic is being examined. To determine the number of new households the plant generates, the models were shocked independently with all regional linkages removed. The number of new jobs and households thereby created became the basis for simulating the increase in the demand for land resulting from housing demand.

Four situations were modeled conforming to the game-theoretical results in Section 3.2. Government involvement was modeled as a change in zoning and/or the issue of building permits sufficient to accommodate the plant and housing. Table 6.7 summarizes the four modeled simulations, with Fort Collins as A, and Loveland as B.

Consistent with Table 3.2 the simulations were set up as follows: For (Agreement, Agreement) a split of the development burden was imposed, namely Fort Collins(A) was given the new firm while Loveland(B) was shocked with the precalculated housing demand increase. The two models were then allowed to iterate until a steady-state solution was

Table 6.7: Course of City Action as Modeled

		Town B (Loveland)	
		Agreement	Go-it-Alone
Town A (Fort Collins)	Agreement	Firm placed in A & homes in B.	B attracts both firm and homes. A does nothing
	Go-it-Alone	A attracts both firm and homes. B does nothing	A and B both rezone enough land for firm and homes

achieved. In this case Fort Collins is assumed not to want to zone land for residential growth. The reasons underlying this assumption are varied, however Helsley and Strange (1995) and Brueckner (1998) argue that cities choose to restrict land area to raise total land rents, thereby benefiting landowners and the city government as well. Thus, Fort Collins is interested in accommodating the manufacturing plant, but would rather have households live elsewhere. If Loveland, as the regional follower is unable to attract the firm, it may well choose to find its benefits where it may and zone/issue building permits to accommodate the workers attracted by Fort Collins' new firm.

For either of the (Agreement, Go-it-Alone) cells, one city was given both the firm and the precalculated housing demand while the other was left alone. The models were then run to convergence. Due to the regional interlinkings and reaction functions, the town that does nothing(Agreement) was not excluded from the impact of the shock but adjusted to equilibrium. In the Stackelberg disequilibrium case, both towns were given their respective predetermined housing demand land increase. For this case, the firm was given to town A as it had the lower wage rates, and thus appeared more attractive from the outset. To eliminate any potential effects of the convergence process, each simulation was run five times to check for consistency of results.

The simulations comprise the following changes: Once again the initial value of exports (CX0) in the manufacturing sector was increased by the amounts in Table 6.8 for each town respectively. Additionally, land supply(LAS) or population(NPRG) values were altered to match the specific game theoretic being modeled. For the Stackelberg disequilibrium condition, Fort Collins was arbitrarily assigned the winner of both the firm and housing. Imposing the above alterations to the base model data as required, the models were re-

Table 6.8: Values Altered for Simulation Set #2

Situation	Parameter Changed	Fort Collins	Loveland
Agree, Agree	CX0	5.7%	0%
	NRPG	-0.5%	1.8%
Agree, Go-Alone	CX0	0.0%	7.7%
	NRPG	0.0%	1.08%
Go-Alone, Agree	CX0	5.2%	0.0%
	NRPG	0.47%	0.0%
GoAlone,GoAlone	CX0	0.5%	0.0%
	NRPG	0.37%	0.0%
	LAS(Manuf)	69.0%	82.0%
	LAS(HS1-3)	5.0%	12.8%

estimated. The results of the simulations are summarized in a consistent manner in Table 6.13. However, to provide a better understanding of the relative changes within the cities that generated Table 6.13, some additional results from the various scenarios are presented in Tables 6.9 - 6.12.

As can be seen, the reaction of the households in the model to the differing scenarios is not neutral, there are in fact decided differences. Most interesting are the relative effects on household income between the scenarios. Notice how, in Table 6.12, even though Fort Collins is given the firm and employment in town increases, households are worse off. This is a direct result of falling land values due to the excessively generous zoning and an increase in relative prices generated by migration and in-commuters from Loveland. These commuters, attracted by employment and higher wages, increase consumer demand in Fort Collins, thereby helping to create an overall higher price level in Fort Collins. Loveland in this subsimulation, not only loses household income from lower land values, but also suffers from reduced in-town expenditures due to the loss of those who find economic benefit from commuting to Fort Collins to work.

Looking at the simulations as a whole, a pattern similar to that discussed in Section 6.1 once again arises. Despite simulation controls designed to limit the amount of indirect effects. Loveland has greater gains from increases in population or manufacturing. This is seen most clearly when comparing the results between Tables 6.10 and 6.11. When each town is resepctively given both the manufacturing plant and the houses. Loveland's households gain 4.37% in income. This is considerably more than the 0.72% increase in household income that Fort Collins earns in a similar situation. This is particularly interesting as the employment or wage increases, 1.01% vs 0.73%. are much closer in proximity. Loveland's households seem to gain considerably from the increase in property (land) values brought about by the increased development. Overall, when faced with economic growth, Loveland seems to be better able to absorb the increases without generating diseconomies.

The impacts seen in the tables discussed above also find their way through to Table 6.13, and so also to the political decision makers. This is not particularly surprising as Table 6.13 is composed of values which are a function of the taxes collected within the cities. However. direct inference is not a foregone conclusion as the previous tables have only indirectly considered the costs associated with growth. Table 6.13 on the other hand presents not only the value of the increase/decrease in taxes collected. but also the cost that the government bears in servicing the growth or development.

Table 6.9: Household Impacts: Agree,Agree

City	Change in HH Income(mil $)	Percentage Change	Employment Change	Percentage Employment Change %
Fort Collins	10.4	0.53%	267	0.99%
Loveland	35.9	4.19%	290	1.07%

Table 6.10: Household Impacts: Agree,Go-Alone

City	Change in HH Income(mil $)	Percentage Change	Employment Change	Percentage Employment Change %
Fort Collins	-0.75	-0.04%	19	0.07%
Loveland	37.6	4.37%	267	1.01%

Table 6.11: Household Impacts: Go-Alone,Agree

City	Change in HH Income(mil $)	Percentage Change	Employment Change	Percentage Employment Change %
Fort Collins	14.2	0.72%	346	0.73%
Loveland	-3.61	-0.42%	-14	-0.05%

Table 6.12: Household Impacts: Go-Alone, Go-Alone

City	Change in HH Income(mil $)	Percentage Change	Employment Change	Percentage Employment Change %
Fort Collins	-1.2	-0.06%	279	1.03%
Loveland	-28.4	-3.3%	-74	-.28%

Recalling Section 3.2, these results represent new tax revenues above the base calibrated values generated by the 200 employee shock, including induced effects. For example, the scenario (Agreement, Go-it-Alone), in other words, Loveland gets everything, generates $910.9 thousand of "profits" for Loveland (where "profit" is once again tax revenues minus the direct costs of growth). This revenue can be used by the town government for a variety of purposes, to expand, increase pay, or enlarge its influence. The results generated from the CGE simulations appear to confirm the theoretical analysis presented in Table 3.1. Household distributions and the overall level of real income are least detrimentally impacted when the model simulated the co-ordination of growth in both towns. Such results are likely the result of a combined reduction of spillover effects and a balancing of the cost burden of the growth. Likewise, the most costly alternative for the region proved to be no regional co-ordination or cut-throat competition. This outcome yielded large spillover effects in Fort Collins.

Table 6.13: Net Change in City Revenue (in Thousand $)

		Loveland	
		Agreement	Go-it-Alone
Fort Collins	Agreement	(604.2, 687.8)	(21.1, 910.9)
	Go-it-Alone	(735.4, 7.2)	(-12.1, -36.9)

reducing the ability of households to live there, while simultaneously imposing similar costs on Loveland's economy.

The result for Loveland in (Agreement, Go-it-Alone) is of some interest. The advantage of acquiring the firm remains significantly greater for Loveland(B), despite not being the regional leader. This may indicate that, despite the similarities between the two towns, Loveland finds itself in a position where scale economies outweigh scale-diseconomies by a greater amount, compared to Fort Collins. Once again, one may argue that Fort Collins is closer to its equilibrium city size, and that Loveland might benefit from further development of some kind.

Chapter 7

Conclusion

The above analysis demonstrates the advantages and feasibility of constructing CGE models for almost any size towns. The results reveal significantly different outcomes across cities, particularly in such important areas as relative wages, household migration, commuting and land use zoning. Thus, disaggregated CGE models have an important place or potential role to play in policy consulting and economic impact analysis. There are many issues that towns and cities face that are unique to each municipality and models need to be constructed in a way that captures that fact. The data sources and organization methods outlined above provide a basis for sound analysis. Additionally, not only do these methods and sources generate specific models, they do so with an economy of effort and time therefore allowing the researcher to undertake more often revisions and/or projects that may have once seemed too burdensome.

The results provided as example are interesting and have specific/unique insights about each town or city examined. Models constructed as such, do react differently to changes despite nearly identical underlying structure. The approach used in this study bridges the gap between theoretical models and data intensive CGE models and can aid the policy maker at the city or town level to help make policy decisions. There is a clear need for this type of analysis in the market, cities and towns face ever more difficult decisions concerning all mater of problems, models and methods such as those in this study can provide an important voice to the debate, one that is perhaps all too needed.

While the model results are not inconsistent with the theoretical framework presented. there is room for improvement. A logical extension is to consider the types of policy instruments that cities have at their disposal and to focus the simulations on determining optimal instruments and levels. Most important here would be the effect of changes in the property tax rates, as these by themselves can change the amount of land available. Additionally. one might examine the effects of differing goals; maximizing household income vs. maximizing government revenue.

Unfortunately, the game-theoretic currently provides only a framework or motivation for analysis in this study. Logical extensions to the methodology developed herein revolve around altering the model to yield the payoff matrices directly. without the level of intrusion currently required. This would have the added benefit of allowing relative prices and costs to be the deciding factor in firm and housing placement rather than the direct whims of the modeler.

Likewise the model is burdened by the use of fairly restrictive functional forms in consumption. Ideally it would be better to use some form that allowed greater control of substitution between goods. and afforded the modeler to opportunity to work with less competitive market structure. Unfortunately, likely forms such as the Almost Ideal Demand System (AIDS) are made intractable by the number of elasticities which must be specified. Without econometric basis, these elasticities are impossible to quantify. and so more promising functional forms are rendered unusable.

That said. this study argues that political decisions within a region are usually made independently without real regard for their impact upon other cities within the region. Such independence is not necessarily bad: however. for some cities, this study argues that there are benefits to willingly coordinating growth policy with a larger neighbor. Larger cities within a region tend to exercise a greater role in determining the regional character or success of regional policies. If growth decisions were considered less independently. with the individual cities acting as if they were components within a regional framework. outcomes would be different. Those outcomes would likely be superior to the blind actions of individual cities determining growth policy irrespective of what their neighbors are undertaking. Such a sharing of power usually does not come willingly. However if tools such as ones developed in this study were readily available to policy makers, perhaps the underlying climate might change.

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Appendix A

Model Notation

A.1 Notation

The following notational conventions are employed for this model: Endogenous Variables are in Roman alphabet lower case. Exogenous Variables are in Roman alphabet lower case with overbar $\bar{x}$. Parameters are in Greek alphabet lower case. Sets have lower case Roman as a member of upper case Roman. Alias of sets are employed when a set is used within an equation defined over that set as i' or j.

A.2 Summary of Set, Parameter and Variable Names

Sets	**Dimension**	**Symbolic**	**GAMS**
Factors	3	f∈F	F
Governments - All	15	g∈G	G
Governments - Revenue Collection Sources	8	g∈GX	GX
Governments - Factor Taxes	2	g∈GF	GF
Governments - Per Household Taxes	3	g∈GH	GH
Governments - Income Taxes	1	g∈GI	GI
Governments - Capital Income Taxes	2	g∈GK	GK
Governments - Endogenous Purchases	6	g∈GN	GN
Governments - Sales or Excise Taxes	4	g∈GS	GS
Governments - Transfer Payments	1	g∈GWN	GWN
Governments - Exogenous Transfer Payments	4	g∈GWX	GWX
Households	7	h∈H	H
Housing Sevices	4	i∈H	HS
All Industries	25	i∈I or j∈I	I
Production Industries	17	i∈IP or j∈IP	IP
All Social Accounting Matrix Accounts	51	z∈Z	Z

Parameters	Dimension	Symbolic	GAMS
Input Output Coefficients	51 x 51	-	A(Z.Z1)
Domestic Input Output Coefficients	25 x 25	α_{ij}	AD(Z.Z1)
Government Spending Shares of Net Income	30 x 15	α_{ig} ,α_{fg}	AG(Z.G)
Factor Share Exponenets in Production Function	2 x 25	α_{fi}	ALPHA(F.I)
Initial Shares of Consumption	25 x 7	α_{ih}	ALPHA(I.H)
Income Elasticities of Demand	25 x 7	β_{ih}	BETA(I.H)
Capital Coefficient Matrix (CAPCOM)	25 x 25	β_{ij}	CCM(I.J)
Depreciation Rate	1	δ	DEPR
Export Price Elasticities	25	η_i^{ee}	ETAE(I)
Investment Supply Elasticity	1	η_i	ETAI
Labor Supply Elasticities with respect to Incomes	7	η_h^{lls}	ETALS(H)
Labor Supply Elasticity with respect to TP's	7	η_h^{llp}	ETATP(H)
Response of In-Migration to Unemployment	7	η_h^{uu}	ETAU(H)
External Wage	1 x 25	Exwage	EXWAGE(L.I)
Production Function Scale	25	γ_i	GAMMA(I)
Types of Inter-Government Transfers (MISC file)	15 x 15	-	IGTD(G.G1)
Correction Factor between Households and Jobs	1x 6	ϵ	JOBCOR(L.H)
Cross-Price Elasticities	25 x 25	$\lambda_{ii'}$	LAMBDA(I.J)
Miscellaneous Industry Parameters (MISC file)	25 x 7	-	MISC(Z.*)
Income Tax Table Data in Input File (MISC file)	7 x 7	-	MISCG(G.H.*)
Miscellaneous Household Parameters (MISC file)	7 x 7	-	MISCH(H.*)
Natural Rate of Population Growth	7	π_η	NRPG(H)
Substitution Exponent in Production Function	25	ρ_i	RHO(I)
Social Accounting Matrix (SAM)	51 x 51	-	SAM(Z.Z1)
Consumption Sales & Excise Tax Rates	4 x 25	τ_{gi}^{cc}	TAUC(G.I)
Factor Tax Rates	2 x 3 x 51	τ_{gfz}	TAUF(G.F.Z)
Factor Taxes applied to Factors (MISC file)	2 x 3	-	TAUFF(GF.G)
Employee Portion of Factor Taxes	2 x 3	τ_{gf}	TAUFH(G.F)
Experimental Factor Tax Rates	2 x 3 x 51	τ_{gfz}^{xx}	TAUFX(G.F.Z)
Government Sales & Excise Tax Rates	4 x 25	τ_{gi}^{gg}	TAUG(G.I)
Household Taxes other than PIT	1 x 7	τ_{gh}	TAUH(G.H)
Import Duty Rates	25	τ_{gi}^{mm}	TAUM(G.I)
Investment Sales & Excise Tax Rates	4 x 25	τ_{gi}^{nn}	TAUN(G.I)
Sales and Excise Tax Rates	4 x 25	τ_{qi}^{qq}	TAUQ(G.I)
Intermediate Good Sales & Excise Tax Rates	4 x 25	τ_{gi}^{vv}	TAUV(G.I)
Per Household Personal Income Taxes	15 x 7	t_{gh}	PIT(G.H)
Percent of Households Receiving TP's (MISC file)	7 x 5	τ_{hg}^{ppc}	TPC(H.G)

Variables	Dimension	Symbolic	GAMS
Public Consumption	25 x 15	c_{ig}	CG(I.G)
Private Consumption	25 x 7	c_{ih}	CH(I.H)
Gross Investment by Sector of Source	25	c_{in}	CN(I)
Consumer Price Index	7	p_h	CPI(H)
Exports	25	e_i	CX(I)
Domestic Share of Domestic Consumption	25	d_i	D(I)
Domestic Supply	25	q_i	DS(I)
Sectoral Factor Demand	3 x 25	u_{fi}	FD(F.I)
Commuting In	1 x 1	cmo	CMO
Commuting Out	1 x 1	cmi	CMI
Number of Households	7	a_h	HH(H)
Number of Non-Working Households	7	a_h^{nn}	HN(H)
Number of Working Households	7	a_h^{ww}	HW(H)
Inter-Governmental Transfers	15 x 15	$b_{ig'}$	IGT(G.G1)
Investment Tax Credit	25	t_i	ITC(I)
Capital Stock	25	u_{Ki}^{ss}	KS(I)

Imports	25	m_i	M(I)
Gross Investment by Sector of Destination	25	n_i	N(I)
Net Capital Inflow	1	z	NKI
Aggregate Price	25	p_i	P(I)
Aggregate Price including Sales/Excise Taxes	25	p_i^{cc}	PC(I)
Domestic Producer Price	25	p_i^{dd}	PD(I)
Producer Price Index	1	p	PPI
Value Added Price	25	p_i^{vva}	PVA(I)
World Price (Rest of State and Rest of World)	25	p_i^{ww}	PW(I)
Sectoral Factor Rental Rates	3 x 51	r_{fi}, r_{gi}	R(Z,I)
Economy Wide Scalar for Factor Rental Rates	3	ra_f	RA(F)
Government Savings	15	s_g	S(G)
Private Savings	7	s_h	S(H)
State Personal Income	1	q	SPI
Transfer Payments	7 x 15	w_{hg}	TP(H,G)
Intermediate Goods	25	v_i	V(I)
Factor Income	3	y_f	Y(F)
Government Income	15	y_g	Y(G)
Household Income	7	y_h	Y(H)
Household after Tax Income including TP's	7	y_i^{dd}	YD(H)

Appendix B

Sectors to SIC to IMPLAN Bridge

Industry	Sect.	SIC	IMPLAN	Description
Ag Prod	1	111	11	Wheat
Ag Prod	1	112	11	Rice
Ag Prod	1	115	12	Corn
Ag Prod	1	116	21	Soybeans
Ag Prod	1	119	18	Cash Grains
Ag Prod	1	119	20	Cash Grains
Ag Prod	1	119	21	Cash Grains
Ag Prod	1	131	10	Cotton
Ag Prod	1	132	15	Tobacco
Ag Prod	1	133	19	Sugarcane & Sugar Beets
Ag Prod	1	134	18	Irish Potatoes
Ag Prod	1	139	12	Field Crops, Except Cash Grains
Ag Prod	1	139	13	Field Crops, Except Cash Grains
Ag Prod	1	139	14	Field Crops, Except Cash Grains
Ag Prod	1	139	18	Field Crops, Except Cash Grains
Ag Prod	1	139	20	Field Crops, Except Cash Grains
Ag Prod	1	139	21	Field Crops, Except Cash Grains
Ag Prod	1	161	18	Vegetables & Melons
Ag Prod	1	171	16	Berry Crops
Ag Prod	1	172	16	Grapes
Ag Prod	1	173	17	Tree Nuts
Ag Prod	1	173	21	Tree Nuts
Ag Prod	1	174	16	Citrus Fruits
Ag Prod	1	175	16	Deciduous Tree Fruits
Ag Prod	1	179	16	Fruits & Tree Nuts
Ag Prod	1	179	17	Fruits & Tree Nuts
Ag Prod	1	181	22	Floriculture & Nursery
Ag Prod	1	181	23	Floriculture & Nursery
Ag Prod	1	182	23	Food Crops Grown Under Cover
Ag Prod	1	191	1	Farms, Primarily Crop
Ag Prod	1	191	2	Farms, Primarily Crop
Ag Prod	1	191	3	Farms, Primarily Crop
Ag Prod	1	191	4	Farms, Primarily Crop
Ag Prod	1	191	5	Farms, Primarily Crop
Ag Prod	1	191	6	Farms, Primarily Crop
Ag Prod	1	191	7	Farms, Primarily Crop
Ag Prod	1	191	8	Farms, Primarily Crop
Ag Prod	1	191	9	Farms, Primarily Crop
Ag Prod	1	191	10	Farms, Primarily Crop
Ag Prod	1	191	11	Farms, Primarily Crop
Ag Prod	1	191	12	Farms, Primarily Crop
Ag Prod	1	191	13	Farms, Primarily Crop
Ag Prod	1	191	14	Farms, Primarily Crop
Ag Prod	1	191	15	Farms, Primarily Crop
Ag Prod	1	191	16	Farms, Primarily Crop
Ag Prod	1	191	17	Farms, Primarily Crop
Ag Prod	1	191	18	Farms, Primarily Crop

Ag Prod	1	191	19	Farms, Primarily Crop
Ag Prod	1	191	20	Farms, Primarily Crop
Ag Prod	1	191	22	Farms, Primarily Crop
Ag Prod	1	191	23	Farms, Primarily Crop
Ag Prod	1	211	5	Beef Cattle Feedlots
Ag Prod	1	212	3	Beef Cattle, Except Feedlots
Ag Prod	1	212	4	Beef Cattle, Except Feedlots
Ag Prod	1	212	8	Beef Cattle, Except Feedlots
Ag Prod	1	213	7	Hogs
Ag Prod	1	214	6	Sheep & Goats
Ag Prod	1	219	2	Livestock, Except Dairy & Poultry
Ag Prod	1	219	3	Livestock, Except Dairy & Poultry
Ag Prod	1	219	4	Livestock, Except Dairy & Poultry
Ag Prod	1	219	5	Livestock, Except Dairy & Poultry
Ag Prod	1	219	6	Livestock, Except Dairy & Poultry
Ag Prod	1	219	7	Livestock, Except Dairy & Poultry
Ag Prod	1	219	8	Livestock, Except Dairy & Poultry
Ag Prod	1	219	9	Livestock, Except Dairy & Poultry
Ag Prod	1	219	10	Livestock, Except Dairy & Poultry
Ag Prod	1	219	11	Livestock, Except Dairy & Poultry
Ag Prod	1	219	12	Livestock, Except Dairy & Poultry
Ag Prod	1	219	13	Livestock, Except Dairy & Poultry
Ag Prod	1	219	14	Livestock, Except Dairy & Poultry
Ag Prod	1	219	15	Livestock, Except Dairy & Poultry
Ag Prod	1	219	16	Livestock, Except Dairy & Poultry
Ag Prod	1	219	17	Livestock, Except Dairy & Poultry
Ag Prod	1	219	18	Livestock, Except Dairy & Poultry
Ag Prod	1	219	19	Livestock, Except Dairy & Poultry
Ag Prod	1	219	20	Livestock, Except Dairy & Poultry
Ag Prod	1	219	21	Livestock, Except Dairy & Poultry
Ag Prod	1	219	22	Livestock, Except Dairy & Poultry
Ag Prod	1	219	23	Livestock, Except Dairy & Poultry
Ag Prod	1	241	1	Dairy Farms
Ag Prod	1	251	2	Broiler, Fryers, & Roaster Chickens
Ag Prod	1	252	2	Chicken Eggs
Ag Prod	1	253	2	Turkey & Turkey Eggs
Ag Prod	1	254	26	Poultry Hatcheries
Ag Prod	1	259	1	Poultry & Eggs
Ag Prod	1	259	2	Poultry & Eggs
Ag Prod	1	259	3	Poultry & Eggs
Ag Prod	1	259	4	Poultry & Eggs
Ag Prod	1	259	5	Poultry & Eggs
Ag Prod	1	259	6	Poultry & Eggs
Ag Prod	1	259	7	Poultry & Eggs
Ag Prod	1	259	8	Poultry & Eggs
Ag Prod	1	259	9	Poultry & Eggs
Ag Prod	1	259	10	Poultry & Eggs
Ag Prod	1	259	11	Poultry & Eggs
Ag Prod	1	259	12	Poultry & Eggs
Ag Prod	1	259	13	Poultry & Eggs
Ag Prod	1	259	14	Poultry & Eggs
Ag Prod	1	259	15	Poultry & Eggs
Ag Prod	1	259	16	Poultry & Eggs
Ag Prod	1	259	17	Poultry & Eggs
Ag Prod	1	259	18	Poultry & Eggs
Ag Prod	1	259	19	Poultry & Eggs
Ag Prod	1	259	20	Poultry & Eggs
Ag Prod	1	259	21	Poultry & Eggs
Ag Prod	1	259	22	Poultry & Eggs
Ag Prod	1	259	23	Poultry & Eggs
Ag Prod	1	271	9	Fur-Bearing Animals & Rabbits
Ag Prod	1	272	9	Horses & Other Equines
Ag Prod	1	273	9	Animal Aquaculture
Ag Prod	1	279	9	Animal Specialities
Ag Prod	1	279	26	Animal Specialities
Ag Prod	1	291	1	Farms, Primarily Livestock & Animals

Ag Prod	1	291	2	Farms, Primarily Livestock & Animals
Ag Prod	1	291	3	Farms, Primarily Livestock & Animals
Ag Prod	1	291	4	Farms, Primarily Livestock & Animals
Ag Prod	1	291	5	Farms, Primarily Livestock & Animals
Ag Prod	1	291	6	Farms, Primarily Livestock & Animals
Ag Prod	1	291	7	Farms, Primarily Livestock & Animals
Ag Prod	1	291	8	Farms, Primarily Livestock & Animals
Ag Prod	1	291	9	Farms, Primarily Livestock & Animals
Ag Prod	1	291	10	Farms, Primarily Livestock & Animals
Ag Prod	1	291	11	Farms, Primarily Livestock & Animals
Ag Prod	1	291	12	Farms, Primarily Livestock & Animals
Ag Prod	1	291	13	Farms, Primarily Livestock & Animals
Ag Prod	1	291	14	Farms, Primarily Livestock & Animals
Ag Prod	1	291	15	Farms, Primarily Livestock & Animals
Ag Prod	1	291	16	Farms, Primarily Livestock & Animals
Ag Prod	1	291	17	Farms, Primarily Livestock & Animals
Ag Prod	1	291	18	Farms, Primarily Livestock & Animals
Ag Prod	1	291	19	Farms, Primarily Livestock & Animals
Ag Prod	1	291	20	Farms, Primarily Livestock & Animals
Ag Prod	1	291	21	Farms, Primarily Livestock & Animals
Ag Prod	1	291	22	Farms, Primarily Livestock & Animals
Ag Prod	1	291	23	Farms, Primarily Livestock & Animals
Ag Prod	1	811	24	Timber Tracts
Ag Prod	1	831	24	Forest Nurseries & Gathering of Forest
Ag Prod	1	851	26	Forestry Services
Ag Prod	1	912	25	Finfish
Ag Prod	1	913	25	Shellfish
Ag Prod	1	919	25	Miscellaneous Marine
Ag Prod	1	921	26	Fish Hatcheries & Preserves
Ag Prod	1	971	24	Hunting & Trapping, & Game
Ag. Proc	2	2011	58	Meat Packing Plants
Ag. Proc	2	2013	59	Sausages & Other Prepared Meats
Ag. Proc	2	2015	60	Poultry Slaughtering & Processing
Ag. Proc	2	2021	61	Creamery Butter
Ag. Proc	2	2022	62	Natural, Processed, & Imitation Cheese
Ag. Proc	2	2023	63	Dry, Condensed, & Evaporated Dairy
Ag. Proc	2	2024	64	Ice Cream & Frozen Desserts
Ag. Proc	2	2026	65	Fluid Milk
Ag. Proc	2	2032	66	Canned Specialties
Ag. Proc	2	2033	67	Canned Fruits, Vegetables, Preserves, Jams, & Jellies
Ag. Proc	2	2034	68	Dried & Dehydrated Fruits, Vegetables, & Soup Mixes
Ag. Proc	2	2035	69	Pickled Fruits & Vegetables, Vegetable Sauces & Seasonings, & Salad Dressings
Ag. Proc	2	2037	70	Frozen Fruits, Fruit Juices & Vegetables
Ag. Proc	2	2038	71	Frozen Specialties
Ag. Proc	2	2041	72	Flour & Other Grain Mill
Ag. Proc	2	2043	73	Cereal Breakfast Foods
Ag. Proc	2	2044	74	Rice Milling
Ag. Proc	2	2045	75	Prepared Flour Mixes & Doughs
Ag. Proc	2	2046	76	Wet Corn Milling
Ag. Proc	2	2047	77	Dog & Cat Food
Ag. Proc	2	2048	78	Prepared Feed & Feed Ingredients for Animals & Fowls, Except Dogs & Cats
Ag. Proc	2	2051	79	Bread & Other Bakery , Except Cookies & Crackers
Ag. Proc	2	2052	80	Cookies & Crackers
Ag. Proc	2	2053	79	Frozen Bakery , Except Bread
Ag. Proc	2	2061	81	Cane Sugar, Except Refining
Ag. Proc	2	2062	81	Cane Sugar Refining
Ag. Proc	2	2063	81	Beet Sugar
Ag. Proc	2	2064	82	Candy & Other Confectionery
Ag. Proc	2	2066	83	Chocolate & Cocoa
Ag. Proc	2	2067	84	Chewing Gum
Ag. Proc	2	2068	85	Salted & Roasted Nuts & Seeds
Ag. Proc	2	2074	86	Cottonseed Oil Mills
Ag. Proc	2	2075	87	Soybean Oil Mills
Ag. Proc	2	2076	88	Vegetable Oil Mills, Except Corn, Cottonseed, & Soybeans

Ag. Proc	2	2077	89	Animal & Marine Fats & Oils
Ag. Proc	2	2079	90	Shortening, Table Oils, Margarine, & Other Edible Fats & Oils
Ag. Proc	2	2082	91	Malt Beverages
Ag. Proc	2	2083	92	Malt
Ag. Proc	2	2084	93	Wines, Brandy, & Brandy Spirits
Ag. Proc	2	2085	94	Distilled & Blended Liquors
Ag. Proc	2	2086	95	Bottled & Canned Soft Drinks & Carbonated Waters
Ag. Proc	2	2087	96	Flavoring Extracts & Flavoring Syrups NEC
Ag. Proc	2	2091	97	Canned & Cured Fish & Seafood
Ag. Proc	2	2092	98	Prepared Fresh or Frozen Fish & Seafoods
Ag. Proc	2	2095	99	Roasted Coffee
Ag. Proc	2	2096	100	Potato Chips, Corn Chips, & Similar Snacks
Ag. Proc	2	2097	101	Manufactured Ice
Ag. Proc	2	2098	102	Macaroni, Spaghetti, Vermicelli, & Noodles
Ag. Proc	2	2099	103	Food Preparations
Ag. Proc	2	3523	309	Farm Machinery & Equip.
Ag. Proc	2	3556	330	Food Machinery
Ag. Ser	3	711	26	Soil Preparation Services
Ag. Ser	3	721	26	Crop Planting, Cultivating, & Protecting
Ag. Ser	3	722	26	Crop Harvesting, Primarily by Machine
Ag. Ser	3	723	26	Crop Preparation Services For Market, except Cotton Ginning
Ag. Ser	3	724	26	Cotton Ginning
Ag. Ser	3	740	493	Veterinary Services
Ag. Ser	3	741	493	Veterinary Services For Livestock
Ag. Ser	3	742	493	Veterinary Services for Animals
Ag. Ser	3	751	26	Livestock Services, Except Veterinary
Ag. Ser	3	752	26	Animal Specialty Services, Except Veterinary
Ag. Ser	3	761	26	Farm Labor Contractors & Crew Leaders
Ag. Ser	3	762	26	Farm Management Services
Comp Manf.	4	3571	339	Electronic Computers
Comp Manf.	4	3572	340	Computer Storage Devices
Comp Manf.	4	3575	341	Computer Terminals
Comp Manf.	4	3577	342	Computer Peripheral Equip.
Constr.	5	1521	48	General Contractors-Single-Family Houses
Constr.	5	1522	49	General Contractors-Residential Buildings, Other Than Single-Family
Constr.	5	1531	51	Operative Builders
Constr.	5	1541	49	General Contractors-Industrial Buildings & Warehouses
Constr.	5	1542	49	General Contractors-Nonresidential Buildings, Other than Industrial Buildings & Warehouses
Constr.	5	1611	51	Highway & Street Constr., Except Elevated Highways
Constr.	5	1622	50	Bridge, Tunnel, & Elevated Highway Constr.
Constr.	5	1623	50	Water, Sewer, Pipeline, & Communications & Power Line Constr.
Constr.	5	1629	49	Heavy Constr.
Constr.	5	1711	55	Plumbing, Heating, & Air-Conditioning
Constr.	5	1721	48	Painting & Paper Hanging
Constr.	5	1731	48	Electrical
Constr.	5	1741	48	Masonry, Stone Setting, & Other Stone
Constr.	5	1742	49	Plastering, Drywall, Acoustical, & Insulation
Constr.	5	1743	49	Terrazzo, Tile, Marble, & Mosaic
Constr.	5	1751	49	Carpentry
Constr.	5	1752	49	Floor Laying & Other Floor
Constr.	5	1761	48	Roofing, Siding, & Sheet Metal
Constr.	5	1771	49	Concrete
Constr.	5	1781	49	Water Well Drilling
Constr.	5	1791	49	Structural Steel Erection
Constr.	5	1793	49	Glass & Glazing
Constr.	5	1794	49	Excavation
Constr.	5	1795	49	Wrecking & Demolition
Constr.	5	1796	49	Installation or Erection of Building Equip.
Constr.	5	1799	49	Special Trade Contractors
Ele & 2nd	6	8211	495	Elementary & Secondary Schools
FIRE	7	6011	456	Federal Reserve Banks
FIRE	7	6019	456	Central Reserve Depository Institutions
FIRE	7	6021	456	National Commercial Banks

FIRE	7	6022	456	State Commercial Banks
FIRE	7	6029	456	Commercial Banks
FIRE	7	6035	456	Savings Institutions, Federally Chartered
FIRE	7	6036	456	Savings institutions, Not Federally Chartered
FIRE	7	6061	456	Credit Unions, Federally Chartered
FIRE	7	6062	456	Credit Unions, Not Federally Chartered
FIRE	7	6081	456	Branches & Agencies of Foreign Banks
FIRE	7	6082	456	Foreign Trade & International Banking Institutions
FIRE	7	6091	456	Nondeposit Trust Facilities
FIRE	7	6099	456	Functions Related to Deposit Banking
FIRE	7	6111	457	Federal & Federally-Sponsored Credit Agencies
FIRE	7	6141	457	Personal Credit Institutions
FIRE	7	6153	457	Short-Term Business Credit Institutions, Except Agricultural
FIRE	7	6159	457	Miscellaneous Business Credit Institutions
FIRE	7	6162	457	Mortgage Bankers & Loan Correspondents
FIRE	7	6163	457	Loan Brokers
FIRE	7	6211	458	Security Brokers, Dealers, & Flotation Companies
FIRE	7	6221	458	Commodity Contracts Brokers & Dealers
FIRE	7	6231	458	Security & Commodity Exchanges
FIRE	7	6282	458	Investment Advice
FIRE	7	6289	458	Services Allied With Exchange of Securities or Commodities
FIRE	7	6311	459	Life Insurance
FIRE	7	6321	459	Accident & Health Insurance
FIRE	7	6324	459	Hospital & Medical Service Plans
FIRE	7	6331	459	Fire, Marine, & Casualty Insurance
FIRE	7	6351	459	Surety Insurance
FIRE	7	6361	459	Title Insurance
FIRE	7	6371	459	Pension, Health, & Welfare Funds
FIRE	7	6399	459	Insurance Carriers
FIRE	7	6411	460	Insurance Agents, Brokers, & Service
FIRE	7	6512	462	Operators of Nonresidential Buildings
FIRE	7	6513	462	Operators of Apartment Buildings
FIRE	7	6514	462	Operators of Dwellings Other Than Apartment Buildings
FIRE	7	6515	462	Operators of Residential Mobile Home Sites
FIRE	7	6517	462	Lessors of Railroad Property
FIRE	7	6519	462	Lessors of Real Property
FIRE	7	6531	462	Real Estate Agents & Managers
FIRE	7	6541	462	Title Abstract Offices
FIRE	7	6552	462	Land Subdividers & Developers, Except Cemeteries
FIRE	7	6553	462	Cemetery Subdividers & Developers
FIRE	7	6712	457	Offices of Bank Holding Companies
FIRE	7	6719	457	Offices of Holding Companies
FIRE	7	6722	457	Management Investment Offices, Open-End
FIRE	7	6726	457	Unit Investment Trusts, Face-Amount Certificate Offices, & Closed-End Management Investment Offices
FIRE	7	6732	502	Education, Religious, & Charitable Trusts
FIRE	7	6733	457	Trusts, Except Edu., Religious, & Charitable
FIRE	7	6792	457	Oil Royalty Traders
FIRE	7	6794	457	Patent Owners & Lessors
FIRE	7	6798	457	Real Estate Investment Trusts
FIRE	7	6799	457	Investors
Lodge	8	7011	463	Hotels & Motels
Lodge	8	7021	463	Rooming & Boarding Houses
Lodge	8	7041	463	Organization Hotels & Lodging Houses, on Membership Basis
Gov't	9	9111	509	Executive Offices
Gov't	9	9121	509	Legislative Bodies
Gov't	9	9131	509	Executive & Legislative Offices, Combined
Gov't	9	9199	509	General Government
Gov't	9	9211	509	Courts
Gov't	9	9221	505	Police Protection
Gov't	9	9222	509	Legal Counsel & Prosecution
Gov't	9	9223	505	Correctional Institutions
Gov't	9	9224	505	Fire Protection
Gov't	9	9229	505	Public Order & Safety
Gov't	9	9311	509	Public Finance, Taxation, & Monetary Policy
Gov't	9	9411	509	Administration of Edu. Programs

Gov't	9	9431	509	Administration of Public Health Programs
Gov't	9	9441	509	Administration of Social, Human Resource & Income Maintenance Programs
Gov't	9	9451	509	Administration of Veterans' Affairs, Except Health Insurance
Gov't	9	9511	509	Air & Water Resource & Solid Waste Management
Gov't	9	9512	509	Land, Mineral, Wildlife, & Forest Conservation
Gov't	9	9531	509	Administration of Housing Programs
Gov't	9	9532	509	Administration of Urban Planning & Community & Rural Development
Gov't	9	9611	509	Administration of General Economic Programs
Gov't	9	9621	509	Regulation & Administration of Transportation Programs
Gov't	9	9631	509	Regulation & Administration of Communications, Electric, Gas, & Other Utilities
Gov't	9	9641	509	Regulation of Agricultural Marketing & Commodities
Gov't	9	9651	509	Regulation, Licensing, & Inspection of Miscellaneous Commercial Sectors
Gov't	9	9661	509	Space Research & Technology
Gov't	9	9711	509	National Security
Gov't	9	9721	509	International Affairs
Gov't	9	9999	509	Nonclassifiable Establishments
High Service	10	7371	475	Computer Programming Services
High Service	10	7372	475	Prepackaged Software
High Service	10	7373	475	Computer Integrated Systems Design
High Service	10	7374	475	Computer Processing & Data Preparation & Processing Services
High Service	10	7375	475	Information Retrieval Services
High Service	10	7376	475	Computer Facilities Management Services
High Service	10	7377	475	Computer Rental & Leasing
High Service	10	7378	475	Computer Maintenance & Repair
High Service	10	7379	475	Computer Related Services
High Service	10	8011	490	Offices & Clinics of Doctors of Medicine
High Service	10	8021	490	Offices & Clinics of Dentists
High Service	10	8031	490	Offices & Clinics of Doctors of Osteopathy
High Service	10	8041	490	Offices & Clinics of Chiropractors
High Service	10	8042	490	Offices & Clinics of Optometrists
High Service	10	8043	490	Offices & Clinics of Podiatrists
High Service	10	8049	490	Offices & Clinics of Health Practitioners
High Service	10	8051	491	Skilled Nursing Care Facilities
High Service	10	8052	491	Intermediate Care Facilities
High Service	10	8059	491	Nursing & Personal Care Facilities
High Service	10	8062	492	General Medical & Surgical Hospitals
High Service	10	8063	492	Psychiatric Hospitals
High Service	10	8069	492	Specialty Hospitals, Except Psychiatric
High Service	10	8071	493	Medical Laboratories
High Service	10	8072	493	Dental Laboratories
High Service	10	8082	493	Home Health Care Services
High Service	10	8092	493	Kidney Dialysis Centers
High Service	10	8093	493	Specialty Outpatient Facilities
High Service	10	8099	493	Health & Allied Services
High Service	10	8111	494	Legal Services
High Service	10	8711	506	Engineering Services
High Service	10	8712	506	Architectural Services
High Service	10	8713	506	Surveying Services
High Service	10	8721	507	Accounting, Auditing, & Bookkeeping Services
High Service	10	8731	509	Commercial Physical & Biological Research
High Service	10	8732	509	Commercial Economic, Sociological, & Edu. Research
High Service	10	8733	509	Noncommercial Research Organizations
High Service	10	8734	509	Testing Laboratories
High Service	10	8741	508	Management Services
High Service	10	8742	508	Management Consulting Services
High Service	10	8743	508	Public Relations Services
High Service	10	8744	508	Facilities Support Management Services
High Service	10	8748	508	Business Consulting Services
Low Service	11	780	27	Landscape Service
Low Service	11	781	27	Landscape Counseling & Planning
Low Service	11	782	27	Lawn & Garden Services
Low Service	11	783	27	Ornamental Shrub & Tree Services

Low Service	11	7032	463	Sporting & Recreational Camps
Low Service	11	7033	463	Recreational Vehicle Parks & Campsites
Low Service	11	7211	464	Power Laundries, Family & Commercial
Low Service	11	7212	464	Garment Pressing, & Agents for Laundries & Drycleaners
Low Service	11	7213	464	Linen Supply
Low Service	11	7215	464	Coin-Operated Laundries & Drycleaning
Low Service	11	7216	464	Drycleaning Plants, Except Rug Cleaning
Low Service	11	7217	464	Carpet & Upholstery Cleaning
Low Service	11	7218	464	Industrial Launderers
Low Service	11	7219	464	Laundry & Garment Services
Low Service	11	7221	465	Photographic Studios, Portrait
Low Service	11	7231	466	Beauty Shops
Low Service	11	7241	466	Barber Shops
Low Service	11	7251	464	Shoe Repair Shops & Shoeshine Parlors
Low Service	11	7261	467	Funeral Services & Crematories
Low Service	11	7291	468	Tax Return Preparation Services
Low Service	11	7299	468	Miscellaneous Personal Services
Low Service	11	7311	469	Advertising Agencies
Low Service	11	7312	469	Outdoor Advertising Services
Low Service	11	7313	469	Radio, Television, & Publishers' Advertising Reps.
Low Service	11	7319	469	Advertising
Low Service	11	7322	470	Adjustment & Collection Services
Low Service	11	7323	470	Credit Reporting Services
Low Service	11	7331	470	Direct Mail Advertising Services
Low Service	11	7334	471	Photocopying & Duplicating Services
Low Service	11	7335	471	Commercial Photography
Low Service	11	7336	471	Commercial Art & Graphic Design
Low Service	11	7338	470	Secretarial & Court Reporting Services
Low Service	11	7342	472	Disinfecting & Pest Control Services
Low Service	11	7349	472	Building Cleaning & Maintenance Services
Low Service	11	7352	473	Medical Equip. Rental & Leasing
Low Service	11	7353	473	Heavy Constr. Equip. Rental & Leasing
Low Service	11	7359	473	Equip. Rental & Leasing
Low Service	11	7361	474	Employment Agencies
Low Service	11	7363	474	Help Supply Services
Low Service	11	7381	476	Detective, Guard, & Armored Car Services
Low Service	11	7382	476	Security Systems Services
Low Service	11	7383	470	News Syndicates
Low Service	11	7384	471	Photofinishing Laboratories
Low Service	11	7389	470	Business Services
Low Service	11	7513	477	Truck Rental & Leasing, Without Drivers
Low Service	11	7514	477	Passenger Car Rental
Low Service	11	7515	477	Passenger Car Leasing
Low Service	11	7519	477	Utility Trailer & Recreational Vehicle Rental
Low Service	11	7521	478	Automobile Parking
Low Service	11	7532	479	Top, Body, & Upholstery Repair Shops & Paint Shops
Low Service	11	7533	479	Automotive Exhaust System Repair Shops
Low Service	11	7534	479	Tire Retreading & Repair Shops
Low Service	11	7536	479	Automotive Glass Replacement Shops
Low Service	11	7537	479	Automotive Transmission Repair Shops
Low Service	11	7538	479	General Automotive Repair Shops
Low Service	11	7539	479	Automotive Repair Shops
Low Service	11	7542	478	Carwashes
Low Service	11	7549	479	Automotive Services, Except Repair & Carwashes
Low Service	11	7622	480	Radio & Television Repair Shops
Low Service	11	7623	480	Refrigeration & Air-Conditioning Services & Repair Shops
Low Service	11	7629	480	Electrical & Electronic Repair Shops
Low Service	11	7631	481	Watch, Clock, & Jewelry Repair
Low Service	11	7641	481	Reupholstery & Furniture Repair
Low Service	11	7692	482	Welding Repair
Low Service	11	7694	482	Armature Rewinding Shops
Low Service	11	7699	482	Repair Shops & Related Services
Low Service	11	7812	483	Motion Picture & Video Tape Production
Low Service	11	7819	483	Services Allied to Motion Picture Production
Low Service	11	7822	483	Motion Picture & Video Tape Distribution
Low Service	11	7829	483	Services Allied to Motion Picture Distribution

Low Service	11	7832	483	Motion Picture Theaters, Except Drive-In
Low Service	11	7833	483	Drive-In Motion Picture Theaters
Low Service	11	7841	483	Video Tape Rental
Low Service	11	7911	488	Dance Studios, Schools, & Halls
Low Service	11	7922	484	Theatrical Producers (Except Motion Picture) & Miscellaneous Theatrical Services
Low Service	11	7929	484	Bands, Orchestras, Actors, & Other Entertainers & Entertainment Groups
Low Service	11	7933	485	Bowling Centers
Low Service	11	7941	486	Professional Sports Clubs & Promoters
Low Service	11	7948	487	Racing, Including Track Operations
Low Service	11	7991	489	Physical Fitness Facilities
Low Service	11	7992	488	Public Golf Courses
Low Service	11	7993	488	Coin-Operated Amusement Devices
Low Service	11	7996	488	Amusement Parks
Low Service	11	7997	489	Membership Sports & Recreation Clubs
Low Service	11	7999	488	Amusement & Recreation Services
Low Service	11	8231	497	Libraries
Low Service	11	8243	497	Data Processing Schools
Low Service	11	8244	497	Business & Secretarial Schools
Low Service	11	8249	497	Vocational Schools
Low Service	11	8299	497	Schools & Edu. Services
Low Service	11	8322	500	Individual & Family Social Services
Low Service	11	8331	498	Job Training & Vocational Rehabilitation Services
Low Service	11	8351	499	Child Day Care Services
Low Service	11	8361	501	Residential Care
Low Service	11	8399	500	Social Services
Low Service	11	8412	502	Museums & Art Galleries
Low Service	11	8422	502	Arboreta & Botanical or Zoological Gardens
Low Service	11	8611	503	Business Associations
Low Service	11	8621	503	Professional Membership Organizations
Low Service	11	8631	504	Labor Unions & Similar Labor Organizations
Low Service	11	8641	504	Civic, Social, & Fraternal Associations
Low Service	11	8651	502	Political Organizations
Low Service	11	8661	505	Religious Organizations
Low Service	11	8699	502	Membership Organizations
Low Service	11	8811	525	Private Households
Low Service	11	8999	507	Services
Manf.	12	2111	104	Cigarettes
Manf.	12	2121	105	Cigars
Manf.	12	2131	106	Chewing & Smoking Tobacco & Snuff
Manf.	12	2141	107	Tobacco Stemming & Redrying
Manf.	12	2211	108	Broadwoven Fabric Mills, Cotton
Manf.	12	2221	108	Broadwoven Fabric Mills, Manmade Fiber & Silk
Manf.	12	2231	108	Broadwoven Fabric Mills, Wool (Including Dyeing & Finishing)
Manf.	12	2241	109	Narrow Fabric & Other Smallware Mills: Cotton, Wool, Silk, & Manmade Fiber
Manf.	12	2251	110	Women's Full-Length & Knee-Length Hosiery, Except Socks
Manf.	12	2252	111	Hosiery
Manf.	12	2253	112	Knit Outerwear Mills
Manf.	12	2254	113	Knit Underwear & Nightwear Mills
Manf.	12	2257	114	Weft Knit Fabric Mills
Manf.	12	2258	114	Lace & Warp Knit Fabric Mills
Manf.	12	2259	115	Knitting Mills
Manf.	12	2261	108	Finishers of Broadwoven Fabrics of Cotton
Manf.	12	2262	108	Finishers of Broadwoven Fabrics of Manmade Fiber & Silk
Manf.	12	2269	116	Finishers of Textiles
Manf.	12	2273	117	Carpets & Rugs
Manf.	12	2281	116	Yarn Spinning Mills
Manf.	12	2282	116	Yarn Texturizing, Throwing, Twisting, & Winding Mills
Manf.	12	2284	118	Thread Mills
Manf.	12	2295	119	Coated Fabrics, Not Rubberized
Manf.	12	2296	120	Tire Cord & Fabrics
Manf.	12	2297	121	Nonwoven Fabrics
Manf.	12	2298	122	Cordage & Twine
Manf.	12	2299	123	Textile Goods

Manf.	12	2311	124	Men's & Boys' Suits, Coats, & Overcoats
Manf.	12	2321	124	Men's & Boys' Shirts, Except Shirts
Manf.	12	2322	124	Men's & Boys' Underwear & Nightwear
Manf.	12	2323	124	Men's & Boys' Neckwear
Manf.	12	2325	124	Men's & Boys' Trousers & Slacks
Manf.	12	2326	124	Men's & Boys' Clothing
Manf.	12	2329	124	Men's & Boys' Clothing
Manf.	12	2331	124	Women's, Misses', & Juniors' Blouses & Shirts
Manf.	12	2335	124	Women's, Misses', & Juniors' Dresses
Manf.	12	2337	124	Women's, Misses' & Juniors' Suits, Skirts, & Coats
Manf.	12	2339	124	Women's, Misses', & Juniors' Outerwear
Manf.	12	2341	124	Women's, Misses', Children's, & Infants' Underwear & Nightwear
Manf.	12	2342	124	Brassieres, Girdles, & Allied Garments
Manf.	12	2353	124	Hats, Caps, & Millinery
Manf.	12	2361	124	Girls', Children's, & Infants' Dresses, Blouses, & Shirts
Manf.	12	2369	124	Girls', Children's, & Infants' Outerwear
Manf.	12	2371	124	Fur Goods
Manf.	12	2381	124	Dress & Gloves, Except Knit & All-Leather
Manf.	12	2384	124	Robes & Dressing Gowns
Manf.	12	2385	124	Waterproof Outerwear
Manf.	12	2386	124	Leather & Sheep-Lined Clothing
Manf.	12	2387	124	Apparel Belts
Manf.	12	2389	124	Apparel & Accessories
Manf.	12	2391	125	Curtains & Draperies
Manf.	12	2392	126	Housefurnishings, Except Curtains & Draperies
Manf.	12	2393	127	Textile Bags
Manf.	12	2394	128	Canvas & Related
Manf.	12	2395	129	Pleating, Decorative & Novelty Stitching, & Tucking for the Trade
Manf.	12	2396	130	Automotive Trimmings, Apparel Findings, & Related
Manf.	12	2397	131	Schiffli Machine Embroideries
Manf.	12	2399	132	Fabricated Textile
Manf.	12	2411	133	Logging
Manf.	12	2421	134	Sawmills & Planing Mills, General
Manf.	12	2426	135	Hardwood Dimension & Flooring Mills
Manf.	12	2429	136	Special Product Sawmills
Manf.	12	2431	137	Millwork
Manf.	12	2434	138	Wood Kitchen Cabinets
Manf.	12	2435	139	Hardwood Veneer & Plywood
Manf.	12	2436	139	Softwood Veneer & Plywood
Manf.	12	2439	140	Structural Wood Members
Manf.	12	2441	141	Nailed & Lock Corner Wood Boxes & Shook
Manf.	12	2448	142	Wood Pallets & Skids
Manf.	12	2449	141	Wood Containers
Manf.	12	2451	143	Mobile Homes
Manf.	12	2452	144	Prefabricated Wood Buildings & Components
Manf.	12	2491	145	Wood Preserving
Manf.	12	2493	146	Reconstituted Wood
Manf.	12	2499	147	Wood
Manf.	12	2511	148	Wood Household Furniture, Except Upholstered
Manf.	12	2512	149	Wood Household Furniture, Upholstered
Manf.	12	2514	150	Metal Household Furniture
Manf.	12	2515	151	Mattresses, Foundations, & Convertible Beds
Manf.	12	2517	152	Wood Television, Radio, Phonograph & Sewing Machine Cabinets
Manf.	12	2519	153	Household Furniture
Manf.	12	2521	154	Wood Office Furniture
Manf.	12	2522	155	Office Furniture, Except Wood
Manf.	12	2531	156	Public Building & Related Furniture
Manf.	12	2541	157	Wood Office & Store Fixtures, Partitions, Shelving, & Lockers
Manf.	12	2542	158	Office & Store Fixtures, Partitions, Shelving, & Lockers, Except Wood
Manf.	12	2591	159	Drapery Hardware & Window Blinds & Shades
Manf.	12	2599	160	Furniture & Fixtures
Manf.	12	2611	161	Pulp Mills

Manf.	12	2621	162	Paper Mills
Manf.	12	2631	163	Paperboard Mills
Manf.	12	2652	164	Setup Paperboard Boxes
Manf.	12	2653	164	Corrugated & Solid Fiber Boxes
Manf.	12	2655	164	Fiber Cans, Tubes, Drums, & Similar
Manf.	12	2656	164	Sanitary Food Containers, Except Folding
Manf.	12	2657	164	Folding Paperboard Boxes, Including Sanitary
Manf.	12	2671	165	Packaging Paper & Plastics Film, Coated & Laminated
Manf.	12	2672	166	Coated & Laminated Paper
Manf.	12	2673	167	Plastics, Foil, & Coated Paper Bags
Manf.	12	2674	168	Uncoated Paper & Multiwall Bags
Manf.	12	2675	169	Die-Cut Paper & Paperboard & Cardboard
Manf.	12	2676	170	Sanitary Paper
Manf.	12	2677	171	Envelopes
Manf.	12	2678	172	Stationery, Tablets, & Related
Manf.	12	2679	173	Converted Paper & Paperboard
Manf.	12	2711	174	Newspapers: Publishing, or Publishing & Printing
Manf.	12	2721	175	Periodicals: Publishing, or Publishing & Printing
Manf.	12	2731	176	Books: Publishing, or Publishing & Printing
Manf.	12	2732	177	Book Printing
Manf.	12	2741	178	Miscellaneous Publishing
Manf.	12	2752	179	Commercial Printing, Lithographic
Manf.	12	2754	179	Commercial Printing, Gravure
Manf.	12	2759	179	Commercial Printing
Manf.	12	2761	180	Manifold Business Forms
Manf.	12	2771	181	Greeting Cards
Manf.	12	2782	182	Blankbooks, Loose-leaf Binders & Devices
Manf.	12	2789	183	Bookbinding & Related
Manf.	12	2791	184	Typesetting
Manf.	12	2796	185	Platemaking & Related Services
Manf.	12	2812	186	Alkalies & Chlorine
Manf.	12	2813	187	Industrial Gases
Manf.	12	2816	188	Inorganic Pigments
Manf.	12	2819	189	Industrial Inorganic Chemicals
Manf.	12	2821	191	Plastics Material & Synthetic Resins, & Nonvulcanizable Elastomers
Manf.	12	2822	192	Synthetic Rubber
Manf.	12	2823	193	Cellulosic Manmade Fibers
Manf.	12	2824	194	Manmade Organic Fibers, Except Cellulosic
Manf.	12	2833	195	Medicinal Chemicals & Botanical
Manf.	12	2834	195	Pharmaceutical Preparations
Manf.	12	2835	195	In Vitro & In Vivo Diagnostic Substances
Manf.	12	2836	195	Biological , Except Diagnostic Substances
Manf.	12	2841	196	Soaps & Other Detergents, Except Speciality Cleaners
Manf.	12	2842	197	Speciality Cleaning, Polishing, & Sanitary Preparations
Manf.	12	2843	198	Surface Active Agents, Finishing Agents, Sulfonated Oils, & Assistants
Manf.	12	2844	199	Perfumes, Cosmetics, & Other Toilet Preparations
Manf.	12	2851	200	Paints, Varnishes, Lacquers, Enamels, & Allied
Manf.	12	2861	201	Gum & Wood Chemicals
Manf.	12	2865	190	Cyclic Organic Crudes & Intermediates, & Organic Dyes & Pigments
Manf.	12	2869	190	Industrial Organic Chemicals
Manf.	12	2873	202	Nitrogenous Fertilizers
Manf.	12	2874	202	Phosphatic Fertilizers
Manf.	12	2875	203	Fertilizers, Mixing Only
Manf.	12	2879	204	Pesticides & Agricultural Chemicals
Manf.	12	2891	205	Adhesives & Sealants
Manf.	12	2892	206	Explosives
Manf.	12	2893	207	Printing Ink
Manf.	12	2895	208	Carbon Black
Manf.	12	2899	209	Chemicals & Chemical Preparations
Manf.	12	2911	210	Petroleum Refining
Manf.	12	2951	211	Asphalt Paving Mixtures & Blocks
Manf.	12	2952	212	Asphalt Felts & Coatings
Manf.	12	2992	213	Lubricating Oils & Greases

Manf.	12	2999	214	NSP of Petroleum & Coal
Manf.	12	3011	215	Tires & Inner Tubes
Manf.	12	3021	216	Rubber & Plastics Footwear
Manf.	12	3052	217	Rubber & Plastics Hose & Belting
Manf.	12	3053	218	Gaskets, Packing, & Sealing Devices
Manf.	12	3061	219	Molded, Extruded, & Lathe-Cut Mechanical Rubber Goods
Manf.	12	3069	219	Fabricated Rubber
Manf.	12	3081	220	Unsupported Plastics Film & Sheet
Manf.	12	3082	220	Unsupported Plastics Profile Shapes
Manf.	12	3083	220	Laminated Plastics Plate, Sheet, & Profile Shapes
Manf.	12	3084	220	Plastics Pipe
Manf.	12	3085	220	Plastics Bottles
Manf.	12	3086	220	Plastics Foam
Manf.	12	3087	220	Custom Compounding of Purchased Plastics Resins
Manf.	12	3088	220	Plastics Plumbing Fixtures
Manf.	12	3089	220	Plastics
Manf.	12	3111	221	Leather Tanning & Finishing
Manf.	12	3131	222	Boot & Shoe Cut Stock & Findings
Manf.	12	3142	223	House Slippers
Manf.	12	3143	224	Men's Footwear, Except Athletic
Manf.	12	3144	224	Women's Footwear, Except Athletic
Manf.	12	3149	224	Footwear, Except Rubber
Manf.	12	3151	225	Leather Gloves & Mittens
Manf.	12	3161	226	Luggage
Manf.	12	3171	227	Women's Handbags & Purses
Manf.	12	3172	228	Personal Leather Goods, Except Women's Handbags & Purses
Manf.	12	3199	229	Leather Goods
Manf.	12	3211	230	Flat Glass
Manf.	12	3221	231	Glass Containers
Manf.	12	3229	230	Pressed & Blown Glass & Glassware
Manf.	12	3231	230	Glass , Made of Purchased Glass
Manf.	12	3241	232	Cement, Hydraulic
Manf.	12	3251	233	Brick & Structural Clay Tile
Manf.	12	3253	234	Ceramic Wall & Floor Tile
Manf.	12	3255	235	Clay Refractories
Manf.	12	3259	236	Structural Clay
Manf.	12	3261	237	Vitreous China Plumbing Fixtures & China & Earthenware Fittings & Bathroom Accessories
Manf.	12	3262	238	Vitreous China Table & Kitchen Articles
Manf.	12	3263	239	Fine Earthenware (Whiteware) Table & Kitchen Articles
Manf.	12	3264	240	Porcelain Electrical Supplies
Manf.	12	3269	241	Pottery
Manf.	12	3271	242	Concrete Block & Brick
Manf.	12	3272	243	Concrete , Except Block & Brick
Manf.	12	3273	244	Ready-Mixed Concrete
Manf.	12	3274	245	Lime
Manf.	12	3275	246	Gypsum
Manf.	12	3281	247	Cut Stone & Stone
Manf.	12	3291	248	Abrasive
Manf.	12	3292	249	Asbestos
Manf.	12	3295	250	Minerals & Earths, Ground or Otherwise Treated
Manf.	12	3296	251	Mineral Wool
Manf.	12	3297	252	Nonclay Refractories
Manf.	12	3299	253	Nonmetallic Mineral
Manf.	12	3312	254	Steel sand, Blast Furnaces (Including Coke Ovens), & Rolling Mills
Manf.	12	3313	255	Electrometallurgical , Except Steel
Manf.	12	3315	256	Steel Wiredrawing & Steel Nails & Spikes
Manf.	12	3316	257	Cold-Rolled Steel Sheet, Strip, & Bars
Manf.	12	3317	258	Steel Pipe & Tubes
Manf.	12	3321	259	Gray & Ductile Iron Foundries
Manf.	12	3322	259	Malleable Iron Foundries
Manf.	12	3324	259	Steel Investment Foundries
Manf.	12	3325	259	Steel Foundries
Manf.	12	3331	260	Primary Smelting & Refining of Copper
Manf.	12	3334	261	Primary Production of Aluminum

Manf.	12	3339	262	Primary Smelting & Refining of Nonferrous Metals, Except Copper & Aluminum
Manf.	12	3341	263	Secondary Smelting & Refining of Nonferrous Metals
Manf.	12	3351	264	Rolling, Drawing, & Extruding of Copper
Manf.	12	3353	265	Aluminum Sheet, Plate, & Foil
Manf.	12	3354	265	Aluminum Extruded
Manf.	12	3355	265	Aluminum Rolling & Drawing
Manf.	12	3356	266	Rolling, Drawing, & Extruding of Nonferrous Metals, Except Copper & Aluminum
Manf.	12	3357	267	Drawing & Insulating of Nonferrous Wire
Manf.	12	3363	268	Aluminum Die-Castings
Manf.	12	3364	270	Nonferrous Die-Castings, Except Aluminum
Manf.	12	3365	268	Aluminum Foundries
Manf.	12	3366	269	Copper Foundries
Manf.	12	3369	270	Nonferrous Foundries, Except Aluminum & Copper
Manf.	12	3398	271	Metal Heat Treating
Manf.	12	3399	272	Primary Metal
Manf.	12	3411	273	Metal Cans
Manf.	12	3412	274	Metal Shipping Barrels, Drums, Kegs, & Pails
Manf.	12	3421	275	Cutlery
Manf.	12	3423	276	Hand & Edge Tools, Except Machine Tools & Handsaws
Manf.	12	3425	277	Saw Blades & Handsaws
Manf.	12	3429	278	Hardware
Manf.	12	3431	279	Enameled Iron & Metal Sanitary Ware
Manf.	12	3432	280	Plumbing Fixture Fittings & Trim
Manf.	12	3433	281	Heating Equip., Except Electric & Warm Air Furnaces
Manf.	12	3441	282	Fabricated Structural Metal
Manf.	12	3442	283	Metal Doors, Sash, Frames, Molding, & Trim Manuf.
Manf.	12	3443	284	Fabricated Plate (Boiler Shops)
Manf.	12	3444	285	Sheet Metal
Manf.	12	3446	286	Architectural & Ornamental Metal
Manf.	12	3448	287	Prefabricated Metal Buildings & Components
Manf.	12	3449	288	Miscellaneous Structural Metal
Manf.	12	3451	289	Screw Machine
Manf.	12	3452	289	Bolts, Nuts, Screws, Rivets, & Washers
Manf.	12	3462	290	Iron & Steel Forgings
Manf.	12	3463	291	Nonferrous Forgings
Manf.	12	3465	292	Automotive Stamping
Manf.	12	3466	293	Crowns & Closures
Manf.	12	3469	294	Metal Stamping
Manf.	12	3471	295	Electroplating, Plating, Polishing, Anodizing, & Coloring
Manf.	12	3479	296	Coating, Engraving, & Allied Services
Manf.	12	3482	297	Small Arms Ammunition
Manf.	12	3483	298	Ammunition, Except for Small Arms
Manf.	12	3484	299	Small Arms
Manf.	12	3489	300	Ordnance & Accessories
Manf.	12	3491	301	Industrial Valves
Manf.	12	3492	301	Fluid Power Valves & Hose Fittings
Manf.	12	3493	302	Steel Springs, Except Wire
Manf.	12	3494	303	Valves & Pipe Fittings
Manf.	12	3495	304	Wire Springs
Manf.	12	3496	304	Miscellaneous Fabricated Wire
Manf.	12	3497	305	Metal Foil & Leaf
Manf.	12	3498	303	Fabricated Pipe & Pipe Fittings
Manf.	12	3499	306	Fabricated Metal
Manf.	12	3511	307	Steam, Gas, & Hydraulic Turbines, & Turbine Generator Set Units
Manf.	12	3519	308	Internal Combustion Engines
Manf.	12	3524	310	Lawn & Garden Tractors & Home Lawn & Garden Equip.
Manf.	12	3531	311	Constr. Machinery & Equip.
Manf.	12	3532	312	Mining Machinery & Equip., Except Oil & Gas Field Machinery & Equip.
Manf.	12	3533	313	Oil & Gas Field Machinery & Equip.
Manf.	12	3534	314	Elevators & Moving Stairways
Manf.	12	3535	315	Conveyors & Conveying Equip.
Manf.	12	3536	316	Overhead Traveling Cranes, Hoists, & Monorail Systems

Manf.	12	3537	317	Industrial Trucks, Tractors, Trailers, & Stackers
Manf.	12	3541	318	Machine Tools, Metal Cutting Type
Manf.	12	3542	319	Machine Tools, Metal Forming Type
Manf.	12	3543	320	Industrial Patterns
Manf.	12	3544	321	Special Dies & Tools, Die Sets, Jigs & Fixtures, & Industrial Molds
Manf.	12	3545	321	Cutting Tools, Machine Tool Accessories, & Machinists' Precision Measuring Devices
Manf.	12	3546	322	Power-Driven Handtools
Manf.	12	3547	323	Rolling Mill Machinery & Equip.
Manf.	12	3548	324	Electric & Gas Welding & Soldering Equip.
Manf.	12	3549	325	Metalworking Machinery
Manf.	12	3552	326	Textile Machinery
Manf.	12	3553	327	Woodworking Machinery
Manf.	12	3554	328	Paper Industries Machinery
Manf.	12	3555	329	Printing Trades Machinery & Equip.
Manf.	12	3559	331	Special Industry Machinery
Manf.	12	3561	332	Pumps & Pumping Equip.
Manf.	12	3562	333	Ball & Roller Bearings
Manf.	12	3563	332	Air & Gas Compressors
Manf.	12	3564	334	Industrial & Commercial Fans & Blowers & Air Purification Equip.
Manf.	12	3565	335	Packaging Machinery
Manf.	12	3566	336	Speed Changers, Industrial High-Speed Drives, & Gears
Manf.	12	3567	337	Industrial Process Furnaces & Ovens
Manf.	12	3568	336	Mechanical Power Transmission Equip.
Manf.	12	3569	338	General Industrial Machinery & Equip.
Manf.	12	3578	343	Calculating & Accounting Machines, Except Electronic Computers
Manf.	12	3579	344	Office Machines
Manf.	12	3581	345	Automatic Vending Machines
Manf.	12	3582	346	Commercial Laundry, Drycleaning, & Pressing Machines
Manf.	12	3585	347	Air-Conditioning & Warm Air Heating Equip. & Commercial & Industrial Refrigeration Equip.
Manf.	12	3586	348	Measuring & Dispensing Pumps
Manf.	12	3589	349	Service Industry Machinery
Manf.	12	3592	350	Carburetors, Pistons, Piston Rings, & Valves
Manf.	12	3593	351	Fluid Power Cylinders & Actuators
Manf.	12	3594	352	Fluid Power Pumps & Motors
Manf.	12	3596	353	Scales & Balances, Except Laboratory
Manf.	12	3599	354	Industrial & Commercial Machinery & Equip.
Manf.	12	3612	355	Power, Distribution, & Specialty Transformers
Manf.	12	3613	356	Switchgear & Switchboard Apparatus
Manf.	12	3621	357	Motors & Generators
Manf.	12	3624	358	Carbon & Graphite
Manf.	12	3625	359	Relays & Industrial Controls
Manf.	12	3629	360	Electrical Industrial Apparatus
Manf.	12	3631	361	Household Cooking Equip.
Manf.	12	3632	362	Household Refrigerators & Home & Farm Freezers
Manf.	12	3633	363	Household Laundry Equip.
Manf.	12	3634	364	Electric Housewares & Fans
Manf.	12	3635	365	Household Vacuum Cleaners
Manf.	12	3639	366	Household Appliances
Manf.	12	3641	367	Electric Lamp Bulbs & Tubes
Manf.	12	3643	368	Current-Carrying Wiring Devices
Manf.	12	3644	368	Noncurrent-Carrying Wiring Devices
Manf.	12	3645	369	Residential Electric Lighting Fixtures
Manf.	12	3646	369	Commercial, Industrial, & Institutional Electric Lighting Fixtures
Manf.	12	3647	369	Vehicular Lighting Equip.
Manf.	12	3648	369	Lighting Equip.
Manf.	12	3651	370	Household Audio & Video Equip.
Manf.	12	3652	371	Phonograph Records & Prerecorded Audio Tapes & Disks
Manf.	12	3661	372	Telephone & Telegraph Apparatus
Manf.	12	3663	373	Radio & Television Broadcasting & Communications Equip.
Manf.	12	3669	374	Communications Equip.

Manf.	12	3671	375	Electron Tubes
Manf.	12	3672	376	Printed Circuit Boards
Manf.	12	3674	377	Semiconductors & Related Devices
Manf.	12	3675	378	Electronic Capacitors
Manf.	12	3676	378	Electronic Resistors
Manf.	12	3677	378	Electronic Coils, Transformers, & Other Inductors
Manf.	12	3678	378	Electronic Connectors
Manf.	12	3679	378	Electronic Components
Manf.	12	3691	379	Storage Batteries
Manf.	12	3692	380	Primary Batteries, Dry & Wet
Manf.	12	3694	381	Electrical Equip. for Internal Combustion Engines
Manf.	12	3695	382	Magnetic & Optical Recording Media
Manf.	12	3699	383	Electrical Machinery, Equip., & Supplies
Manf.	12	3711	384	Motor Vehicles & Passenger Car Bodies
Manf.	12	3713	385	Truck & Bus Bodies
Manf.	12	3714	386	Motor Vehicle Parts & Accessories
Manf.	12	3715	387	Truck Trailers
Manf.	12	3716	388	Motor Homes
Manf.	12	3721	389	Aircraft
Manf.	12	3724	390	Aircraft Engines & Engine Parts
Manf.	12	3728	391	Aircraft Parts & Auxiliary Equip.
Manf.	12	3731	392	Ship Building & Repairing
Manf.	12	3732	393	Boat Building & Repairing
Manf.	12	3743	394	Railroad Equip.
Manf.	12	3751	395	Motorcycles, Bicycles, & Parts
Manf.	12	3761	396	Guided Missiles & Space Vehicles
Manf.	12	3764	390	Guided Missile & Space Vehicle Propulsion Units & Propulsion Unit Parts
Manf.	12	3769	391	Guided Missile Space Vehicle Parts & Auxiliary Equip.
Manf.	12	3792	397	Travel Trailers & Campers
Manf.	12	3795	398	Tanks & Tank Components
Manf.	12	3799	399	Transportation Equip.
Manf.	12	3812	400	Search, Detection, Navigation, Guidance, Aeronautical, & Nautical Systems & Instruments
Manf.	12	3821	401	Laboratory Apparatus & Furniture
Manf.	12	3822	402	Automatic Controls for Regulating Residential & Commercial Environments & Appliances
Manf.	12	3823	403	Industrial Instruments for Measurement, Display, & Control of Process Variables; & Related
Manf.	12	3824	403	Totalizing Fluid Meters & Counting Devices
Manf.	12	3825	404	Instruments for Measuring & Testing of Electricity & Electrical Signals
Manf.	12	3826	405	Laboratory Analytical Instruments
Manf.	12	3827	406	Optical Instruments & Lenses
Manf.	12	3829	403	Measuring & Controlling Devices
Manf.	12	3841	407	Surgical & Medical Instruments & Apparatus
Manf.	12	3842	408	Orthopedic, Prosthetic, & Surgical Appliances & Supplies
Manf.	12	3843	409	Dental Equip. & Supplies
Manf.	12	3844	410	X-Ray Apparatus & Tubes & Related Irradiation Apparatus
Manf.	12	3845	411	Electromedical & Electrotherapeutic Apparatus
Manf.	12	3851	412	Ophthalmic Goods
Manf.	12	3861	413	Photographic Equip. & Supplies
Manf.	12	3873	414	Watches, Clocks, Clockwork Operated Devices & Parts
Manf.	12	3911	415	Jewelry, Precious Metal
Manf.	12	3914	416	Silverware, Plated Ware, & Stainless Steel Ware
Manf.	12	3915	417	Jewelers' Findings & Materials, & Lapidary
Manf.	12	3931	418	Musical Instruments
Manf.	12	3942	419	Dolls & Stuffed Toys
Manf.	12	3944	420	Games, Toys, & Children's Vehicles, Except Dolls & Bicycles
Manf.	12	3949	421	Sporting & Athletic Goods
Manf.	12	3951	422	Pens, Mechanical Pencils, & Parts
Manf.	12	3952	423	Lead Pencils, Crayons, & Artist's Materials
Manf.	12	3953	424	Marking Devices
Manf.	12	3955	425	Carbon Paper & Inked Ribbons
Manf.	12	3961	426	Costume Jewelry & Costume Novelties, Except Precious Metals
Manf.	12	3965	427	Fasteners, Buttons, Needles, & Pins

Manf.	12	3991	428	Brooms & Brushes
Manf.	12	3993	429	Signs & Advertising Specialties
Manf.	12	3995	430	Burial Caskets
Manf.	12	3996	431	Linoleum, Asphalted-Felt-Base, & Other Hard Surface Floor Coverings
Manf.	12	3999	432	Manuf. Industries
Mining	13	1011	28	Iron Ores
Mining	13	1021	29	Copper Ores
Mining	13	1031	30	Lead & Zinc Ores
Mining	13	1041	31	Gold Ores
Mining	13	1044	32	Silver Ores
Mining	13	1061	33	Ferroalloy Ores, Except Vanadium
Mining	13	1081	34	Metal Mining Services
Mining	13	1094	35	Uranium-Radium-Vanadium Ores
Mining	13	1099	36	Miscellaneous Metal Ores
Mining	13	1221	37	Bituminous Coal & Lignite Surface Mining
Mining	13	1222	37	Bituminous Coal Underground Mining
Mining	13	1231	37	Anthracite Mining
Mining	13	1241	37	Coal Mining Services
Mining	13	1311	38	Crude Petroleum & Natural Gas
Mining	13	1321	39	Natural Gas Liquids
Mining	13	1381	57	Drilling Oil & Gas Wells
Mining	13	1382	57	Oil & Gas Field Exploration Services
Mining	13	1389	57	Oil & Gas Field Services
Mining	13	1411	40	Dimension Stone
Mining	13	1422	40	Crushed & Broken Limestone
Mining	13	1423	40	Crushed & Broken Granite
Mining	13	1429	40	Crushed & Broken Stone
Mining	13	1442	41	Constr. Sand & Gravel
Mining	13	1446	41	Industrial Sand
Mining	13	1455	42	Kaolin & Ball Clay
Mining	13	1459	42	Clay, Ceramic, & Refractory Minerals
Mining	13	1474	43	Potash, Soda, & Borate Minerals
Mining	13	1475	44	Phosphate Rock
Mining	13	1479	45	Chemical & Fertilizer Mineral Mining
Mining	13	1481	46	Nonmetallic Minerals Services Except Fuels
Mining	13	1499	47	Miscellaneous Nonmetallic Minerals, Except Fuels
Comm	14	4812	441	Radiotelephone Communications
Comm	14	4813	441	Telephone Communications, Except Radiotelephone
Comm	14	4822	441	Telegraph & Other Message Communications
Comm	14	4832	442	Radio Broadcasting Stations
Comm	14	4833	442	Television Broadcasting Stations
Comm	14	4841	441	Cable & Other Pay Television Services
Comm	14	4899	441	Communications Services
Eating	15	5810	454	Eating & Drinking
Retail	16	5211	448	Lumber & Other Building Materials Dealers
Retail	16	5231	448	Paint, Glass, & Wallpaper Stores
Retail	16	5251	448	Hardware Stores
Retail	16	5261	448	Retail Nurseries, Lawn & Garden Supply Stores
Retail	16	5271	448	Mobile Home Dealers
Retail	16	5311	449	Department Stores
Retail	16	5331	449	Variety Stores
Retail	16	5399	449	Miscellaneous General Merchandise Stores
Retail	16	5411	450	Grocery Stores
Retail	16	5421	450	Meat & Seafood Markets, Including Freezer Provisioners
Retail	16	5431	450	Fruit & Vegetable Markets
Retail	16	5441	450	Candy, Nut, & Confectionery Stores
Retail	16	5451	450	Dairy Stores
Retail	16	5461	450	Retail Bakeries
Retail	16	5499	450	Miscellaneous Food Stores
Retail	16	5511	451	Motor Vehicle Dealers (New & Used)
Retail	16	5521	451	Motor Vehicle Dealers (Used Only)
Retail	16	5531	451	Auto & Home Supply Stores
Retail	16	5541	451	Gasoline Service Stations
Retail	16	5551	451	Boat Dealers
Retail	16	5561	451	Recreational Vehicle Dealers

Retail	16	5571	451	Motorcycle Dealers
Retail	16	5599	451	Automotive Dealers
Retail	16	5611	452	Men's & Boys' Clothing & Accessory Stores
Retail	16	5621	452	Women's Clothing Stores
Retail	16	5632	452	Women's Accessory & Specialty Stores
Retail	16	5641	452	Children's & Infants' Wear Stores
Retail	16	5651	452	Family Clothing Stores
Retail	16	5661	452	Shoe Stores
Retail	16	5699	452	Miscellaneous Apparel & Accessory Stores
Retail	16	5712	453	Furniture Stores
Retail	16	5713	453	Floor Covering Stores
Retail	16	5714	453	Drapery, Curtain, & Upholstery Stores
Retail	16	5719	453	Miscellaneous Homefurnishings Stores
Retail	16	5722	453	Household Appliance Stores
Retail	16	5731	453	Radio, Television, & Consumer Electronics Stores
Retail	16	5734	453	Computer & Computer Software Stores
Retail	16	5735	453	Record & Prerecorded Tape Stores
Retail	16	5736	453	Musical Instrument Stores
Retail	16	5812	454	Eating & Drinking Places
Retail	16	5813	454	Drinking Places (Alcoholic Beverages)
Retail	16	5912	455	Drug Stores & Proprietary Stores
Retail	16	5921	455	Liquor Stores
Retail	16	5932	455	Used Merchandise Stores
Retail	16	5941	455	Sporting Goods Stores & Bicycle Shops
Retail	16	5942	455	Book Stores
Retail	16	5943	455	Stationery Stores
Retail	16	5944	455	Jewelry Stores
Retail	16	5945	455	Hobby, Toy, & Game Shops
Retail	16	5946	455	Camera & Photographic Supply Stores
Retail	16	5947	455	Gift, Novelty, & Souvenir Shops
Retail	16	5948	455	Luggage & Leather Goods Stores
Retail	16	5949	455	Sewing, Needlework, & Piece Goods Stores
Retail	16	5961	455	Catalog & Mail-Order Houses
Retail	16	5962	455	Automatic Merchandising Machine Operator
Retail	16	5963	455	Direct Selling Establishments
Retail	16	5983	455	Fuel Oil Dealers
Retail	16	5984	455	Liquefied Petroleum Gas (Bottled Gas) Dealers
Retail	16	5989	455	Fuel Dealers
Retail	16	5992	455	Florists
Retail	16	5993	455	Tobacco Stores & Stands
Retail	16	5994	455	News Dealers & Newsstands
Retail	16	5995	455	Optical Goods Stores
Retail	16	5999	455	Miscellaneous Retail Stores
TU	17	4011	433	Railroads, Line-haul Operating
TU	17	4013	433	Railroad Switching & Terminal Establishments
TU	17	4111	434	Local & Suburban Transit
TU	17	4119	434	Local Passenger Transportation
TU	17	4121	434	Taxicabs
TU	17	4131	434	Intercity & Rural Bus Transportation
TU	17	4141	434	Local Bus Charter Service
TU	17	4142	434	Bus Charter Service, Except Local
TU	17	4151	434	School Buses
TU	17	4173	434	Terminal & Service Facilities for Motor Vehicle Passenger Transportation
TU	17	4212	435	Local Trucking Without Storage
TU	17	4213	435	Trucking, Except Local
TU	17	4214	435	Local Trucking with Storage
TU	17	4215	435	Courier Services Except by Air
TU	17	4221	435	Farm Product Warehousing & Storage
TU	17	4222	435	Refrigerated Warehousing & Storage
TU	17	4225	435	General Warehousing & Storage
TU	17	4226	435	Special Warehousing & Storage
TU	17	4231	435	Terminal & Joint Terminal Maintenance Facilities for Motor Freight Transportation
TU	17	4311	513	United States Postal Service
TU	17	4412	436	Deep Sea Foreign Transportation of Freight

TU	17	4424	436	Deep Sea Domestic Transportation of Freight
TU	17	4432	436	Freight Transportation on the Great Lakes - St. Lawrence Seaway
TU	17	4449	436	Water Transportation of Freight
TU	17	4481	436	Deep Sea Transportation of Passengers, Except by Ferry
TU	17	4482	436	Ferries
TU	17	4489	436	Water Transportation of Passengers
TU	17	4491	436	Marine Cargo Handling
TU	17	4492	436	Towing & Tugboat Services
TU	17	4493	436	Marinas
TU	17	4499	436	Water Transportation Services
TU	17	4512	437	Air Transportation, Scheduled
TU	17	4513	437	Air Courier Services
TU	17	4522	437	Air Transportation, Nonscheduled
TU	17	4581	437	Airports, Flying Fields, & Airport Terminal Services
TU	17	4612	438	Crude Petroleum Pipelines
TU	17	4613	438	Refined Petroleum Pipelines
TU	17	4619	438	Pipelines
TU	17	4724	439	Travel Agencies
TU	17	4725	439	Tour Operators
TU	17	4729	439	Arrangement of Passenger Transportation
TU	17	4731	440	Arrangement of Transportation of Freight & Cargo
TU	17	4741	433	Rental of Railroad Cars
TU	17	4783	440	Packing & Crating
TU	17	4785	440	Fixed Facilities & Inspection & Weighing Services for Motor Vehicle Transportation
TU	17	4789	433	Transportation Services
TU	17	4789	435	Transportation Services
TU	17	4922	444	Natural Gas Transmission
TU	17	4923	444	Natural Gas Transmission & Distribution
TU	17	4924	444	Natural Gas Distribution
TU	17	4925	444	Mixed, Manufactured, or Liquefied Petroleum Gas Production &/or Distribution
TU	17	4932	443	Gas & Other Services Combined
TU	17	4939	443	Combination Utilities
TU	17	4953	446	Refuse Systems
TU	17	4959	446	Sanitary Services
TU	17	4961	446	Steam & Air-Conditioning Supply
Univ & JC	18	8221	496	Colleges, Universities, & Professional Schools
Univ & JC	18	8222	496	Junior Colleges & Technical Institutes
Wholesale	19	5012	447	Automobiles & Other Motor Vehicles
Wholesale	19	5013	447	Motor Vehicle Supplies & New Parts
Wholesale	19	5014	447	Tires & Tubes
Wholesale	19	5015	447	Motor Vehicle Parts, Used
Wholesale	19	5021	447	Furniture
Wholesale	19	5023	447	Home Furnishings
Wholesale	19	5031	447	Lumber, Plywood, Millwork, & Wood Panels
Wholesale	19	5032	447	Brick, Stone & Related Constr. Materials
Wholesale	19	5033	447	Roofing, Siding, & Insulation Materials
Wholesale	19	5039	447	Constr. Materials
Wholesale	19	5043	447	Photographic Equip. & Supplies
Wholesale	19	5044	447	Office Equip.
Wholesale	19	5045	447	Computers & Computer Peripheral Equip. & Software
Wholesale	19	5046	447	Commercial Equip.
Wholesale	19	5047	447	Medical, Dental, & Hospital Equip. & Supplies
Wholesale	19	5048	447	Ophthalmic Goods
Wholesale	19	5049	447	Professional Equip. & Supplies
Wholesale	19	5051	447	Metals Service Centers & Offices
Wholesale	19	5052	447	Coal & Other Minerals & Ores
Wholesale	19	5063	447	Electrical Apparatus & Equip. Wiring Supplies, & Constr. Materials
Wholesale	19	5064	447	Electrical Appliances, Television & Radio Sets
Wholesale	19	5065	447	Electronic Parts & Equip.
Wholesale	19	5072	447	Hardware
Wholesale	19	5074	447	Plumbing & Heating Equip. & Supplies (Hydronics)
Wholesale	19	5075	447	Warm Air Heating & Air-Conditioning Equip. & Supplies

Wholesale	19	5078	447	Refrigeration Equip. & Supplies
Wholesale	19	5082	447	Constr. & Mining (Except Petroleum) Machinery & Equip.
Wholesale	19	5083	447	Farm & Garden Machinery & Equip.
Wholesale	19	5084	447	Industrial Machinery & Equip.
Wholesale	19	5085	447	Industrial Supplies
Wholesale	19	5087	447	Service Establishment Equip. & Supplies
Wholesale	19	5088	447	Transportation Equip. & Supplies, Except Motor Vehicles
Wholesale	19	5091	447	Sporting & Recreational Goods & Supplies
Wholesale	19	5092	447	Toys & Hobby Goods & Supplies
Wholesale	19	5093	447	Scrap & Waste Materials
Wholesale	19	5094	447	Jewelry, Watches, Precious Stones, & Precious Metals
Wholesale	19	5099	447	Durable Goods
Wholesale	19	5111	447	Printing & Writing Paper
Wholesale	19	5112	447	Stationery & Office Supplies
Wholesale	19	5113	447	Industrial & Personal Service Paper
Wholesale	19	5122	447	Drugs, Drug Proprietaries, & Druggists' Sundries
Wholesale	19	5131	447	Piece Goods, Notions, & Other Dry Goods
Wholesale	19	5136	447	Men's & Boys' Clothing & Furnishings
Wholesale	19	5137	447	Women's, Children's, & Infants' Clothing & Accessories
Wholesale	19	5139	447	Footwear
Wholesale	19	5141	447	Groceries, General Line
Wholesale	19	5142	447	Packaged Frozen Foods
Wholesale	19	5143	447	Dairy , Except Dried or Canned
Wholesale	19	5144	447	Poultry & Poultry Products
Wholesale	19	5145	447	Confectionery
Wholesale	19	5146	447	Fish & Seafoods
Wholesale	19	5147	447	Meats & Meat
Wholesale	19	5148	447	Fresh Fruits & Vegetables
Wholesale	19	5149	447	Groceries & Related
Wholesale	19	5153	447	Grain & Field Beans
Wholesale	19	5154	447	Livestock
Wholesale	19	5159	447	Farm-Product Raw Materials
Wholesale	19	5162	447	Plastics Materials & Basic Forms & Shapes
Wholesale	19	5169	447	Chemicals & Allied
Wholesale	19	5171	447	Petroleum Bulk Stations & Terminals
Wholesale	19	5172	447	Petroleum & Petroleum Wholesalers, Except Bulk Stations & Terminals
Wholesale	19	5181	447	Beer & Ale
Wholesale	19	5182	447	Wine & Distilled Alcoholic Beverages
Wholesale	19	5191	447	Farm Supplies
Wholesale	19	5192	447	Books, Periodicals, & Newspapers
Wholesale	19	5193	447	Flowers, Nursery Stock, & Florists' Supplies
Wholesale	19	5194	447	Tobacco & Tobacco Products
Wholesale	19	5198	447	Paint, Varnishes, & Supplies
Wholesale	19	5199	447	Nondurable Goods
Elec	20	4911	443	Electric Services
Elec	20	4931	443	Electric & Other Services Combined
Water	21	4941	445	Water Supply
Water	21	4952	445	Sewerage Systems
Water	21	4971	446	Irrigation Systems

Appendix C

The GAMS Code

This Appendix provides a listing of the model code derived from (Berck et al., 1997).

```
$TITLE ft collins ANALYSIS MODEL - ftcoltourcom

*-----------------------------------------------------------------------------------
* 1.1 CONTROLS PLACED ON OUTPUT GENERATION
*-----------------------------------------------------------------------------------

$OFFSYMLIST OFFSYMXREF

*OPTIONS SYSOUT=OFF, SOLPRINT=OFF, LIMROW=0, LIMCOL=0;

*-----------------------------------------------------------------------------------
* 1.2 SET UP FILE FOR SOLUTION VALUES
*-----------------------------------------------------------------------------------

FILE RES /D:\ft collins\ftCOMWS.RES/; RES.PW=250; RES.ND = 6; RES.LW = 20;
RES.NW=20; RES.LJ = 1; PUT RES;


*-----------------------------------------------------------------------------------
* 2. SET DEFINITION
*-----------------------------------------------------------------------------------
* 2.1 EXPLICIT SET DECLARATION
*-----------------------------------------------------------------------------------

SETS  Z  ALL ACCOUNTS IN SOCIAL ACCOUNTING MATRIX /
        AGPRO   AGRICULTURAL PRODUCTION
        AGSER   AGRICULTURE SERVICES
        CONST   CONSTRUCTION
        MINNG   MINING
        AGPRS   AGRICULTURAL PROCESING
        MANUF   MANUFACTURING
        CMANF   COMPUTER MANUFACTURING
        COMMU   COMMUNICATIONS
        ELECT   LOCAL ELECTRIC
        WATER   LOCAL WATER
        RETAL   RETAIL
        FIRE    FINANCE INSURANCE REAL ESTATE
        LODGE   HOTELS MOTELS
        EATING  RESTAURANTS AND BARS
        LWSER   LOW SERVICES
        HGSER   HIGH SERVICES
        TRUTL   TRANSPORTATION AND UTILITIES
        WHOLE   WHOLESALE
        ELE2    LOCAL SCHOOL DISTRICT
        UNIJC   UNIVERSITIES AND JUNIOR COLLEGES
```

```
        HS1     HOUSING SERVICES 1
        HS2     HOUSING SERVICES 2
        HS3     HOUSING SERVICES 3
        HS4     HOUSING SERVICES 4
        LAB     LABOR
        LAND    LAND
        KAP     CAPITAL
        COMMO   COMMUTING OUT
        HH1     HOUSEHOLDS  LOW
        HH2     HOUSEHOLDS  MEDIUM LOW
        HH3     HOUSEHOLDS  MEDIUM
        HH4     HOUSEHOLDS  MEDIUM HIGH
        HH5     HOUSEHOLDS  HIGH
        HH6     HOUSEHOLDS  SUPER HIGH
        INVES   INVESTMENT
        USSOC   SOCIAL SECURITY
        USPIT   FEDERAL AND STATE INCOME TAX
        FEDTX   FEDERAL AND STATE FEES AND TAX
        CNPRP   COUNTY PROPERTY TAX
        CYNVT   CITY INVENTORY TAX
        CYSTX   CITY SALES TAX
        CYUSE   CITY USE TAX
        CYORV   CITY OTHER REVENUE
        CYGF    CITY GENERAL FUND
        STFED   STATE AND FEDERAL GOVERNMENT
        CYPOL   CITY POLICE
        CYTRA   CITY TRANSPORTATION
        CYLPR   CITY LIBRARY PARKS AND REC
        CYFIR   CITY FIRE
        CYADM   CITY ADMINISTRATION
        ROW     REST OF WORLD /

F(Z)      FACTORS                  / LAB, KAP, LAND/

*       CMI(Z)    COMMUTERS IN             /COMMI/

CM(Z)   COMMUTERS OUT           /COMMO/

L(F)      LABOR                 /LAB/

LA(F)     LAND                  /LAND/

K(F)      CAPITAL               /KAP/

G(Z)      GOVERNMENTS           / USSOC, USPIT, FEDTX, CNPRP, CYNVT, CYSTX, CYUSE,
                                CYORV, CYGF,  STFED, CYPOL, CYTRA,
                                 CYLPR, CYFIR, CYADM/

GN(G)     ENDOGENOUS GOVERNMENTS   / STFED, CYPOL, CYTRA, CYLPR, CYFIR, CYADM /

GNL(G)  1OCAL  ENDOGENOUS GOVERNMENTS   / CYPOL, CYTRA, CYLPR, CYFIR, CYADM /

GX(G)     EXOGENOUS GOVERMENTS     / USSOC, USPIT, FEDTX, CNPRP, CYNVT, CYSTX,CYUSE, CYORV/

GS(G)     SALES OR EXCISE TAXES    / FEDTX, CYNVT, CYSTX, CYORV /

GK(G)     USE TAX (KTAX)         / CYUSE/

GL(G)      LAND TAXES            / CNPRP/

GF(G)     FACTOR TAXES             / USSOC, CNPRP/

GI(G)     INCOME TAX UNITS         / USPIT /

GH(G)     HOUSEHOLD TAX UNITS      / FEDTX, CNPRP, CYORV /
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```
GY(G)     EXOGNOUS TRANSFER PMT   /USSOC, USPIT, FEDTX, CNPRP, CYNVT, CYSTX, CYUSE, CYORV, STFED/

GTA(G)    EXOGNOUS TRANSFER PMT   /USSOC, USPIT, FEDTX, CNPRP, CYNVT, CYSTX, CYUSE, CYORV, CYGF,
                                   STFED/

GT(G)     ENDOGENOUS TRANSFER PMT   / CYGF, STFED /

H(Z)      HOUSEHOLDS              / HH1, HH2, HH3, HH4, HH5, HH6 /

IG(Z)     I+G SECTORS             /AGPRO, AGSER, CONST, MINNG,
                                   AGPRS, MANUF, CMANF, COMMU, ELECT, WATER,
                                   RETAL, FIRE, LODGE, EATING, LWSER, HGSER, TRUTL,
                                   WHOLE, HS1, HS2, HS3, HS4, STFED,CYPOL,
                                   CYFIR, CYTRA, CYADM, CYLPR, ELE2, UNIJC/

I(IG)      INDUSTRY SECTORS       /AGPRO, AGSER, CONST, MINNG,
                                   AGPRS, MANUF, CMANF, COMMU, ELECT, WATER,
                                   RETAL, FIRE, LODGE, EATING, LWSER, HGSER, TRUTL,
                                   WHOLE, HS1, HS2, HS3, HS4,ELE2,UNIJC/

IG2(IG)   ENDOGENOUS GOVERNMENTS   / STFED, CYPOL, CYTRA, CYLPR, CYFIR, CYADM /

IP(I)     PRODUCTION SECTORS     /AGPRO, AGSER, CONST, MINNG,
                                  AGPRS, MANUF, CMANF, COMMU, ELECT, WATER,
                                  RETAL, FIRE, LODGE, EATING, LWSER, HGSER, TRUTL,
                                  WHOLE, ELE2, UNIJC/

FG(IG)    PRODUCTION GOV.         /STFED, CYPOL, CYFIR, CYTRA, CYADM, CYLPR/

HD(IG)    HOUSING SERV.DEMAND      /HS1, HS2, HS3, HS4/

T         SIMMLOOP                 /BASE, TODAY/

R1H       REPORT 1 FOR SCALARS     / GFREV, SFREV, PIT,
                                     DGF, DSF, DDRE, PDRE, SPI,COMM,COMMO,
                                     GN, NKI, HH, W, R,RL, L , K, HN, HW, GFSAV, LD,CMO,
                                     CMI, HC, SSC, LAND, LAS /

R2H       REPORT 2 FOR STATUS      / M-STAT, S-STAT /

MS        LABELS FOR MODEL STATUS  / OPTIMAL, LOCALOP, UNBOUND,
                                        INFSBLE, INFSLOC, INFSINT,
                                        NOOPTML, MIPSOLN, NOINTGR,
                                        INFSMIP, UNUSED,  UNKNOWN,
                                        NOSOLUT /

SS        LABELS FOR SOLVER STATUS / OK, ITERATE, RESRCE,
                                        SOLVER,  EVALUATE,NOTKNWN,
                                        NOTUSED, PRE-PROC,SETUP,
                                        SLVFAIL, SLVINTER,POST-PROC,
                                        METSYS /

*------------------------------------------------------------------------------------------
* 2.2 ALIASES
*------------------------------------------------------------------------------------------

ALIAS (I,J), (I,I1), (Z,Z1), (F,F1), (G,G1), (G,G2), (GI,GI1), (GS,GS1),(GX,GX1), (GN,GN1),
(GH,GH1), (GF,GF1), (H,H1), (HD, HD1), (IP,JP), (IG,JG),(GY,GY1), (GT,GT1),
(GY, GY2), (GNL, GNL1);

*------------------------------------------------------------------------------------------
* 3. PARAMETERS AND EXOGENOUS VARIABLES
*------------------------------------------------------------------------------------------
* 3.1 SOCIAL ACCOUNTING MATRIX, CAPITAL COEFFICIENT MATRIX AND PARAMETERS
*------------------------------------------------------------------------------------------

TABLE SAM(Z,Z1) SOCIAL ACCOUNTING MATRIX
$ONDELIM
$INCLUDE D:\FT COLLINS\FCCOMSAMHCWS3.CSV
```

```
$OFFDELIM
$INCLUDE D:\FT COLLINS\FCmiscCOMHC1WS3.prn
TABLE BB(I,IG) CAPITAL COMP
$ONDELIM
$INCLUDE D:\FT COLLINS\CAPCOM3WS2.CSV
$OFFDELIM
*was originaly capcomtest
*---------------------------------------------------------------------------------
* 3.2 PARAMETER DECLARATION
*---------------------------------------------------------------------------------

SCALARS

 ETAL2          CRCE     LAND SUPPLY ELASTICITY        / 3.0 /;

PARAMETERS

* PARAMETERS CALCULATED FROM SOCIAL ACCOUNTING MATRIX AND TABLE DATA

A(Z,Z1)         IMPLAN  INPUT OUTPUT COEFFICIENTS
AD(Z,Z1)        IMPLAN  DOMESTIC INPUT OUTPUT COEFFICIENTS
AG(Z,G)         IMPLAN  GOVERNMENT SPENDING SHARES OF NET INCOME
AGFS(Z,G)
ALPHA(F,I)      IMPLAN  FACTOR SHARE EXPONENTS IN PRODUCTION FUNCTION
B(I,IG)
CMOWAGE(L)
CMIWAGE(L)
FCONST(F,I)
GAMMA(I)        CALC    PRODUCTION FUNCTION SCALE
DELTA(I)
*KLAOUT(F,IG)            CAPITAL AND LAND EXCLUSION FROM GOV.
PIT(G,H)
PRIVRET(H)
LFOR(LA)                      PROPORTION OF LAND INCOME    OUTFLOW
KFOR(K)                       PROPORTION OF CAPITAL INCOME  OUTFLOW
GFOR(G)                 PROPORTION OF GOVT INCOME OUTFLOW
* CFOR                     PROPORTION OF COUNTY OUTFLOW
LBBFOR(L)
LBBFAR(L)
out(G1,G1)
SCALEI(F)               COMMUTING IN SCALE FACTOR
SCALEO(F)               COMMUTING OUT SCALE FACTOR
TAUF(G,F,Z)     DOF     FACTOR TAXES
TAUFH(G,F)      DOF     AGG FACTOR TAXES
TAUFL(G,L)      DOF     EMPLOYEE PORTION OF FACTOR TAXES
TAUFLA(G,LA)    DOF     LAND FACTOR TAXES
TAUFK(G,K)      DOF     CAPITAL FACTOR TAXES
TAUFX(G,F,Z)
TAUH(G,H)       DOF     HOUSEHOLD TAXES OTHER THAN PIT
TAUM(G,IG)       DOF     IMPORT DUTY RATES
TAUQ(G,IG)       DOF     AVERAGE SALES TAX RATES
TAUC(G,I)       DOF     EXPERIMENTAL CONSUMPTION SALES TAX RATES
TAUCH(G,HD)             HOUSING CONSUMPTION SALES TAX RATES
TAUV(G,I)       DOF     EXPERIMENTAL CONSUMPTION SALES TAX RATES
TAUN(G,IG)      DOF     EXPERIMENTAL CONSUMPTION SALES TAX RATES
TAUX(G,IG)      DOF     EXPERIMENTAL CONSUMPTION SALES TAX RATES
TAUG(G,I)       DOF     EXPERIMENTAL CONSUMPTION SALES TAX RATES
TAXS(G,GX)      DOF     TAX DESTINATION SHARES
TAXS1(GNL)


* ELASTICITIES AND PIT TAX DATA IMPOSED

BETA(I,H)      CRCE     INCOME ELASTICITY OF DEMAND
BETAH(HD,H)    CAL      INCOME ELASTICITY OF HOUSING DEMAND
ETAD(I)         CALC    DOMESTIC SHARE PRICE ELASTICITIES
ETAE(I)         CRCE     EXPORT ELASTICITIES WITH RESPECT TO DOMESTIC PRICE
ETAI(IG)           CRCE     EXPERIMENTAL INVESTMENT SUPPLY ELASTICITY
ETAIX(K,IG)
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```
ETAL(LA,IG)             LAND ELASTICITY
ETAL1(IG)
ETALB1(IG)
ETALB(L,IG)
ETAM(I)        CRCE     IMPORT ELASTICITIES WITH RESPECT TO DOMESTIC PRICE
ETARA(H)       CRCE     L SUPPLY ELASTICITY WITH RESPECT TO AVERAGE WAGE
ETAPIT(H)      CRCE     L SUPPLY ELASTICITY WITH RESPECT TO TAXES
ETAYD(H)       CRCE     RESPONSIVENESS OF IMMIGRATION TO AFTER TAX EARNINGS
ETAU(H)        CRCE     RESPONSIVENESS OF IMMIGRATION TO UNEMPLOYMENT
ETAPT(H)       CRCE     HOUSEHOLD RESPONSE TO TRANSFER PAYMENTS
EXWGE(L)       CALC    EXTERNAL WAGE
ECOMI(L)       CALC    ELASTICITY OF LABOR SUPPLY FOR IN COMMUTTERS
ECOMO(L)       CALC    ELASTICITY OF LABOR SUPPLY FOR OUT COMMUTTERS
HOUSECOR(H,HD)          HOUSEHOLD HOUSING RELATIONSHIP
JOBCOR(H,L)      CALC    CORRECTION FACTOR BETWEEN HOUSEHOLDS AND JOBS
LAMBDA(I,J)  CRCE      CROSS PRICE ELASTICITIES
LAMBDAH(HD,HD1)        HOUSING CROSS PRICE ELASTCITIES
NRPG(H)        CRCE     NATURAL RATE OF POPULATION GROWTH
RHO(I)         CRCE     EXPONENT IN PRODUCTION FUNCTION


* ARRAYS BUILT TO EXPORT RESULTS TO SEPARATE FILE

R1(R1H,T)      REPORT  SCALAR VARIABLES
R2(R2H,T)      REPORT  SOLVER AND MODEL STATUS VALUES

* INITIAL VALUES OF ENDOGENOUS VARIABLES

CGO(I,G)       DOF     REAL    GOVERNMENT CONSUMPTION
CGOT(I,G)
CHO(I,H)       IMPLAN  REAL    PRIVATE CONSUMPTION
CHOT(I,H)
* CHHO(HD,H)     IMPLAN  REAL    PRIVATE HOUSING CONSUMPTION
CMIO(L)        CALC    REAL    NUMBER COMMUTING IN
CMOO(L)        CALC    REAL    NUMBER COMMUTING OUT
CNO(I)         IMPLAN  REAL    INVESTMENT BY SECTOR OF SOURCE
CNOT(I)
CPIO(H)        CALC    PRICE   CONSUMER PRICE INDICES
* CPIHO(H)       CALC    PRICE   HOUSING PRICE INDEX
CXO(I)         IMPLAN  REAL    EXPORT CONSUMPTION
DO(I)          CALC    RATIO   DOMESTIC SUPPLY SHARE OF DOMESTIC DEMAND
DDO(Z)         CALC    REAL    DOMESTIC DEMAND
DSO(Z)         CALC    REAL    DOMESTIC SUPPLY QUANTITIES
DQO(Z)
FDO(F,Z)       IMPLAN  REAL    FACTOR DEMAND
IGTO(G,GX)     DOF     NOMINAL INTER GOVERNMENTAL TRANSFERS
KSO(K,IG)       CALC    REAL    CAPITAL STOCK
LASO(LA,IG)
HHO(H)         DOF     HHDS    NUMBER OF HOUSEHOLDS
HNO(H)         DOF     HHDS    NUMBER OF NONWORKING HOUSEHOLDS
HWO(H)         DOF     HHDS    NUMBER OF WORKING HOUSEHOLDS
MO(I)          IMPLAN  REAL    IMPORTS
MIO(H)         DOF     REAL    IN MIGRATION
MOO(H)         DOF     REAL    OUT MIGRATION
NO(K,IG)       CALC    REAL    GROSS INVESTMENT BY SECTOR OF DESTINATION
NKIO          CALC    NOMINAL NET CAPITAL INFLOW
KPFORO(K)           CALC   CAPITAL OUTFLOW
LNFORO(LA)          CALC    LAND OUTFLOW
GVFORO(G)          CALC    GOVT OUTFLOW
LBFORO
LBFARO(L)
* CNFORO                  COUNTY OUTFLOW
PO(IG)          CALC    PRICE   AGGREGATE PRICES
PHO(HD)        CALC    PRICE   AGGREGATE HOUSING PRICES
PDO(I)         CALC    PRICE   DOMESTIC PRICES
PVAO(I)        CALC    PRICE   VALUE ADDED PRICES
PWO(I)         CALC    PRICE   EXOGENOUS PRICES IN EXTERNAL MARKETS
PWMO(I)        CALC    PRICE   IMPORT PRICE
QO(Z)          DOF     REAL    SOCIAL ACCOUNTING MATRIX TOTALS
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Q10(Z)
RO(F,Z)        IMPLAN  PRICE   INITIAL SECTORAL RENTAL RATE FOR FACTOR
RAO(F)         IMPLAN  AVERAGE RENTAL RATES FOR FACTORS
SO(Z)          DOF     NOMINAL SAVINGS
SPIO           CALC    NOMINAL STATE PERSONAL INCOME
VO(I)          IMPLAN  REAL    INTERMEDIATE DEMAND
VOT(I)
TP(H,G)       DOF     NOMINAL GOVERNMENT TRANSFER PAYMENTS
TAUFO(G,F,Z)  CALC    SOCIAL SECURITY TAX
YDO(H)         CALC    NOMINAL AFTER TAX TOTAL HOUSEHOLD INCOMES
YO(Z)          CALC    NOMINAL GROSS HOUSEHOLD INCOME
YO1(H)
YTO(G)                  GOV INCOMES
DDCX(I)
GCP10(I)
GCPO ;
*------------------------------------------------------------------------------------------
* 3.3 CALCULATIONS OF PARAMETERS AND INITIAL VALUES
*------------------------------------------------------------------------------------------

* ETAIX=ETAI;

* CALCULATE COLUMN AND ROW TOTALS OF SAM TO COMPARE FOR BALANCE

Q10(Z)=SUM(Z1,SAM(Z,Z1) );

QO(Z)=SUM(Z1,SAM(Z1,Z) );

DQO(Z) = Q10(Z)-QO(Z);

DISPLAY QO, Q10, DQO;
* READ IN ELASTICITY PARAMETERS FROM MISC.PRN

out(G1,G1) = IOUT(G1,G1);

BETA(I,H)=MISC(I,'ETAY');

BETAH(HD,H)=MISC(HD,'ETAY');

DISPLAY BETA, BETAH;

LAMBDA(I,I)=MISC(I,'ETAOP');

LAMBDAH(HD,HD)=MISC(HD,'ETAOP');

ETAE(I)=MISC(I,'ETAE');

ETAM(I)=MISC(I,'ETAM');

RHO(I)=( 1 - MISC(I,'SIGMA') ) / MISC(I,'SIGMA');

ETARA(H)=MISCH(H,'ETARA');

ETAPIT(H)=MISCH(H,'ETAPIT');

ETAPT(H)=MISCH(H,'ETAPT');

ETAYD(H)=MISCH(H,'ETAYD');

NRPG(H)=MISCH(H,'NRPG');

ETAU(H)=MISCH(H,'ETAU');

*ECOMI(F)=MISCL(F,'ECOMI');

ECOMO(L)=5.0;

EXWGE(L)=1.0;
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ECOMI(L)= 1.0;

ETAI(IG)= LANDCAP(IG,'ETAI1');

ETAL1(IG)= LANDCAP(IG,'ETAL1');

ETALB1(IG)= LANDCAP(IG,'ETALB1');

ETAIX('KAP',IG)=ETAI(IG);

ETAL('LAND',IG)=ETAL1(IG);

ETALB('LAB',IG)=ETALB1(IG);

*TAX Rates
TAUC(GS,I)=TAUQ(GS,I);
TAUV(GS,I)=TAUQ(GS,I);
TAUN(GS,I)=TAUQ(GS,I);
TAUG(GS,I)=TAUQ(GS,I);
TAUX(GS,I)=TAUQ(GS,I);

TAUM('CYUSE',I)$(SAM('ROW', I))=SAM('CYUSE',I) / SAM('ROW',I);

TAUFO(G,F,Z)=0;

TAUF(GF,F,I)$(SAM(F,I) AND TAUFF(GF,F))=SAM(GF,I) / SAM(F,I);

TAUF(GF,F,G)$(SAM(F,G) AND TAUFF(GF,F))=SAM(GF,G) / SAM(F,G);

TAUFX(GF,F,Z)=TAUF(GF,F,Z);

TAUFH(GF,F)$(TAUFF(GF,F)) =SAM(GF,F) / SUM(Z, SAM(Z,F));

TAUFL(GF,L)=SAM(GF,L) / SUM(Z, SAM(Z,L));

TAUFLA(GF,LA)=SAM(GF,LA) / SUM(Z, SAM(Z,LA));

TAUFK(GF,K)=SAM(GF,K) / SUM(Z, SAM(Z,K));

TAXS(G,GX)$(IGTD(G,GX) EQ 1)=SAM(G,GX) / SUM(G1$(IGTD(G1,GX) EQ 1), SAM(G1,GX) );

 TAXS1(GNL)=SAM(GNL,'CYGF') / SUM(GNL1, SAM(GNL1,'CYGF'));

* SET INITIAL INTER GOVERNMENTAL TRANSFERS

IGTO(G,GX)=SAM(G,GX);

 DISPLAY TAXS, TAXS1, IGTO;

* SET INITIAL PRICES TO UNITY LESS SALES AND EXCISE TAXES

PWO(I)=1;

PWMO(I)= 1/(1+SUM(GK,TAUM(GK,I)));

PO(I)=1;

PHO(HD)=1;

PDO(I)=1;

CPIO(H)=1;

* CPIHO(H)=1;

* HOUSEHOLD TRANSFER PAYMENTS AND PERSONAL INCOME TAXES
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```
HHO(H)=MISCH(H,'HHO');

HWO(H)=MISCH(H,'HWO');

HNO(H)= HHO(H) - HWO(H);


TP(H,G) = 0;

TP(H,G)$(HNO(H))= SAM(H,G) / ( HNO(H) );

* FACTOR RENTALS

JOBCOR(H,L)= JOBCR(H,L);

HOUSECOR(H,HD) = HOUSCR(H,HD);

RO(F, Z)=1 ;

RO(F ,IG)$EMPLOY(IG,F)=SAM(F ,IG) / (EMPLOY(IG,F)) ;

FDO(F,Z)=EMPLOY(Z,F); DISPLAY FDO;

KSO(K,IG)=FDO(K ,IG);

LASO(LA,IG)=FDO(LA ,IG);

* SHARES FOUND IN THE SOCIAL ACCOUNTING MATRIX DATA

A(Z,Z1)=SAM(Z,Z1) / QO(Z1);

AG(I,G)$(SUM(J, SAM(J,G) ) + SUM(F, SAM(F,G) ) + SUM(GF, SAM(GF,G) ) )
        =SAM(I,G) / ( SUM(J, SAM(J,G) ) + SUM(F, SAM(F,G) )
        + SUM(GF, SAM(GF,G) ));

AGFS('LAB',G)=SAM('LAB',G)+SAM('USSOC',G);

AG(F,G)$(SUM(I, SAM(I,G) ) + SUM(F1, SAM(F1,G) ) + SUM(GF, SAM(GF,G) ) )
        =SAM(F,G) / ( SUM(I, SAM(I,G) ) + SUM(F1, SAM(F1,G) )
        + SUM(GF, SAM(GF,G) ) );

AG('LAB',G)$(SUM(I, SAM(I,G) ) + SUM(F1, SAM(F1,G) ) + SUM(GF, SAM(GF,G) ) )
        =AGFS('LAB',G) / ( SUM(I, SAM(I,G) ) + SUM(F1, SAM(F1,G) )
        + SUM(GF, SAM(GF,G) ) );


* TRADE INTERMEDIATES CONSUMPTION INVESTMENT INITIAL LEVELS

CXO(I)=SAM(I,'ROW')/PO(I) /( 1 + SUM(GS, TAUQ(GS,I) ) );

MO(I)=SAM('ROW',I) / PWMO(I);

VO(I)=SUM(J, SAM(I,J) ) / PO(I) /( 1 + SUM(GS, TAUQ(GS,I) ) );

VOT(I)=SUM(J, SAM(I,J) ) / PO(I) ;

CHO(I,H)=SAM(I,H) / PO(I)/ ( 1 + SUM(GS, TAUQ(GS,I) ) );

CHOT(I,H)=SAM(I,H) / PO(I);

CGO(I,GN)=SAM(I,GN) / PO(I)/ ( 1 + SUM(GS, TAUQ(GS,I) ) );

CGOT(I,GN)=SAM(I,GN) / PO(I);

 DEPR= SUM(IG, SAM(IG,'INVES') ) / (SUM((K,IG), KSO(K,IG)));

NO(K,IG)=(KSO(K,IG)) * (DEPR);

CNO(I)=0;
```

```
B(I,IG) = BB(I,IG);

CNO(I)=SUM(IG, B(I,IG) * SUM(K, NO(K,IG)) ) / PO(I)/ ( 1 + SUM(GS, TAUN(GS,I) ) );

CNOT(I)=SUM(IG, B(I,IG) * SUM(K, NO(K,IG)) )/PO(I)   ;

DDO(I)= SUM(H, CHO(I,H) ) + SUM(G, CGO(I,G) ) + CNO(I) + VO(I);

DO(I)= 1 - (MO(I) / DDO(I));

* CORRECT IMPORT ELASTICITY TO DOMESTIC SHARE ELASTICITY

ETAD(I)= - ETAM(I) * MO(I) / ( DDO(I) * DO(I) );

*  PRODUCTION DATA

DSO(I)=DDO(I) + CXO(I) - MO(I);

AD(I,J)= SAM(I,J) / PO(I) /(1 + SUM(GS, TAUQ(GS, I)))/ DSO(J)   ;

PVAO(I)= PDO(I) - SUM(J, AD(J,I) * PO(J)*(1 + SUM(GS, TAUQ(GS, J))));

RAO(F)=1;

ALPHA(F,I)  =   ( SAM(F,I) + SUM(GF$TAUFF(GF,F), SAM(GF,I) ) )
                / ( SUM(F1, SAM(F1,I) ) + SUM(GF, SAM(GF,I)  ) );

GAMMA(I)    = DSO(I) / ( SUM(F, ALPHA(F,I) * FDO(F,I) ** ( - RHO(I) ) ) ) ** ( -1 / RHO(I) );

 DELTA(I) = DSO(I)/ (PROD(F$ALPHA(F,I),FDO(F,I)**ALPHA(F,I)));


* OTHER DATA

PRIVRET(H) = MISCH(H,'ROWM');

YO(F)= SUM(IG, SAM(F,IG) );

KPFORO(K)=SAM('KAP', 'ROW');

LNFORO(LA)=SAM('LAND', 'ROW');

GVFORO(G) = SAM(G, 'ROW');

A(H,'LAB')=SAM(H,'LAB') / HWO(H)
          / (YO('LAB')+ SAM('LAB','ROW'))*( 1 - SUM(G, TAUFL(G,'LAB') ) );

A(H,'KAP')=SAM(H,'KAP') / HWO(H) / (YO('KAP') + SAM('KAP','ROW'));

A(H,'LAND')=SAM(H,'LAND') / HWO(H)
         / (YO('LAND') + SAM('LAND', 'ROW'))* ( 1 - SUM(G, TAUFLA(G,'LAND')) );

TAUH(GH,H)=SAM(GH,H) / HHO(H);

SO(H)=SAM('INVES',H);

YDO(H)=SUM(I, SAM(I,H) ) + SO(H);

YO(G) = SUM(Z, SAM(G,Z)) - SAM(G,'ROW' );

SO(G)=SAM('INVES',G);

CMIO(L) = 0.01524 ;

CMOO(L) = 0.014647;

CMOWAGE(L) = SAM('COMMO', 'ROW')/CMOO(L);

CMIWAGE(L) = SAM('LAB', 'ROW')/ CMIO(L);
```

```
LFOR(LA)=LNFORO(LA)/(SUM(IG, SAM('LAND', IG)));

KFOR(K)=KPFORO(K)/(SUM(IG, SAM('KAP', IG)));

GFOR(G)$(YO(G))=GVFORO(G)/(YO(G));

DISPLAY GFOR , CMOO;

NKIO = SUM(I, MO(I) * PWMO(I) ) - SUM(I, CXO(I) * PDO(I) )
      - SUM(H, PRIVRET(H)*HNO(H)) - SUM(LA, LNFORO(LA))
      - SUM(K, KPFORO(K)) - SUM(G, GVFORO(G))- SUM(L,CMOWAGE(L)*CMOO(L))
       -SUM(L,CMIWAGE(L)*CMIO(L));

YO(H)= SUM(L,  A(H,L) * HWO(H) / SUM(H1, A(H1,L) * HWO(H1) )
      * (YO(L)+ CMIWAGE(L)*CMIO(L))* ( 1 - SUM(G, TAUFL(G,L) ) ))
      + A(H, 'COMMO')*SUM(L,CMOWAGE(L)*CMOO(L)) + SUM(LA,  A(H,LA)
      * HWO(H) / SUM(H1, A(H1,LA) * HWO(H1)) * (YO(LA) * ( 1 - SUM(G, TAUFLA(G,LA)))
      + LNFORO(LA)) ) + SUM(K,  A(H,K) * HWO(H) / SUM(H1, A(H1,K) * HWO(H1)) * (YO(K)
      * ( 1 - SUM(G, TAUFK(G,K)))+ KPFORO(K)) ) ;

SPIO= SUM(H, YO(H) ) + SUM((H,G), TP(H,G) * HNO(H) )+ SUM(H, PRIVRET(H)*HNO(H));

PIT(GI,H) = SAM(GI,H) / (HHO(H));

MIO(H)=HHO(H) * 0.05;

MOO(H)=HHO(H) * 0.05;

GCPO =SUM((I,H), (CHO(I,H)))+ SUM(I, CNO(I))+ SUM((I,GN), (CGO(I,GN)))
     + SUM(I, CXO(I))-SUM(I, MO(I));

GCP1O(I) = SUM(H, CHO(I,H))+ CNO(I)+ SUM(GN, CGO(I,GN))+ CXO(I)-MO(I);


*-------------------------------------------------------------------------------------
* 4. VARIABLES
*-------------------------------------------------------------------------------------
* 4.1 VARIABLE DECLARATION
*-------------------------------------------------------------------------------------
VARIABLES
CG(I,G)   PUBLIC CONSUMPTION
DFCG(I,G)
CH(I,H)   PRIVATE CONSUMPTION
DFCH(I,H)
*CMI(F)    COMMUTING IN
CMO(L)    COMMUTING OUT
CMI(L)
CN(I)     GROSS INVESTMENT BY SECTOR OF SOURCE
DFCN(IG)
CPI(H)    CONSUMER PRICE INDEX
DFCPI(H)
* CPIH(H)  HOUSING PRICE INDEX
CX(I)     EXPORT DEMAND
DCX(I)
D(I)      DOMESTIC SHARE OF DOMESTIC DEMAND
DFD(I)
DD(I)     DOMESTIC DEMAND
DFDD(I)
DS(I)     DOMESTIC SUPPLY
DFS(I)
FD(F,Z)   SECTORAL FACTOR DEMAND
DFFD(F,Z)
DRR(F,Z)
DM(I)
DY(Z)
DDS(I)
DDD(I)
DCH(I,H)
DLAS(LA,IG)
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TAUTST(F,GN)
GCP
DGCP
GCP1(I)
DGCP1(I)
HH(H)      NUMBER OF HOUSEHOLDS
DFHH(H)
HN(H)      NUMBER OF NONWORKING HOUSEHOLDS
DFHN(H)
HW(H)      NUMBER OF WORKING HOUSEHOLDS
DFHW(H)
IGT(G,G1) INTER GOVERNMENTAL TRANSFERS
KS(K,IG)      CAPITAL FLOW
LAS(LA,IG)     LAND FLOW
M(I)       IMPORTS
N(K,IG)       GROSS INVESTMENT BY SECTOR OF DESTINATION
NKI        NET CAPITAL INFLOW
LNFOR(LA)      LAND OUTFLOW
KPFOR(K)      CAPITAL OUTFLOW
GVFOR(G)      GOVT OUTFLOW
LBFOR
LBFAR(L)
P(I)       AGGREGATE DOMESTIC PRICE PAID BY PURCHASERS
PD(I)      DOMESTIC PRICE RECEIVED BY SUPPLIERS
PVA(I)     VALUE ADDED PRICE
RA(F)      ECONOMY WIDE SCALAR RENTAL RATES OF FACTORS
R(F,Z)     SECTORAL RENTAL RATES
S(Z)       SAVINGS
SPI        STATE PERSONAL INCOME
V(I)       INTERMEDIATE GOODS
Y(Z)       GROSS INCOMES
YD(H)      AFTER TAX TOTAL HOUSEHOLD INCOMES
YT(G,G1)      GOV INCOME;

*-----------------------------------------------------------------------------------------
* 4.2 INITIALIZATION OF VARIABLES AND REMOVING TRACE NUMBERS
*-----------------------------------------------------------------------------------------

P.L(I)=PO(I);            PD.L(I)     = PDO(I);
PVA.L(I)=PVAO(I);        RA.L(F)     = RAO(F);
R.L(F,Z)=RO(F,Z);        CPI.L(H)    = CPIO(H);
CMI.L(L)=CMIO(L);        CMO.L(L)   = CMOO(L);
DS.L(I)=DSO(I);          DD.L(I)     = DDO(I);
V.L(I)=VO(I);            FD.L(F,Z)   = FDO(F,Z);
HH.L(H)=HHO(H);          HN.L(H)     = HNO(H);
HW.L(H)=HWO(H);          KS.L(K,IG)   = KSO(K,IG);
CN.L(I)=CNO(I);          N.L(K,IG)    = NO(K,IG);
D.L(I)=DO(I);            CX.L(I)     = CXO(I);
M.L(I)=MO(I);            NKI.L       = NKIO;
KPFOR.L(K)=KPFORO(K);    LNFOR.L(LA)    = LNFORO(LA);
*CNFOR.L=CNFORO;
GVFOR.L(G)=GVFORO(G);
*TP.L(H,G)=TP(H,G);
Y.L(Z) = YO(Z);
YD.L(H)=YDO(H);
IGT.L(G,GX)=IGTO(G,GX);     CH.L(I,H)    = CHO(I,H);
CG.L(I,G)=CGO(I,G);         S.L(Z)       = SO(Z);
SPI.L=SPIO;
*LAS.L(LA) = LASO(LA);
LAS.L(LA,IG) = LASO(LA,IG);
* CPIH.L(H)=CPIHO(H);

* REMOVE TRACE NUMBERS FOR COMPUTATIONAL PURPOSES

P.L(I)$(ABS(P.L(I))           LT 0.00000001)=0;
PD.L(I)$(ABS(PD.L(I))         LT 0.00000001)=0;
PVA.L(I)$(ABS(PVA.L(I))       LT 0.00000001)=0;
RA.L(F)$(ABS(RA.L(F))         LT 0.000000C1)=0;
R.L(F,Z)$(ABS(R.L(F,Z))       LT 0.00000001)=0;
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CPI.L(H)$(ABS(CPI.L(H))        LT 0.00000001)=0;
CMI.L(L)$(ABS(CMI.L(L))        LT 0.00000001)=0;
CMO.L(L)$(ABS(CMO.L(L))        LT 0.00000001)=0;
DS.L(I)$(ABS(DS.L(I))          LT 0.00000001)=0;
DD.L(I)$(ABS(DD.L(I))          LT 0.00000001)=0;
V.L(I)$(ABS(V.L(I))            LT 0.00000001)=0;
FD.L(F,Z)$(ABS(FD.L(F,Z))      LT 0.0000000001)=0;
HH.L(H)$(ABS(HH.L(H))          LT 0.00000001)=0;
HN.L(H)$(ABS(HN.L(H))          LT 0.00000001)=0;
HW.L(H)$(ABS(HW.L(H))          LT 0.00000001)=0;
KS.L(K,IG)$(ABS(KS.L(K,IG))    LT 0.00000001)=0;
*LAS.L(LA)$(ABS(LAS.L(LA))   LT 0.0000001)=0;
LAS.L(LA,IG)$(ABS(LAS.L(LA,IG)) LT 0.00000001)=0;
CN.L(I)$(ABS(CN.L(I))          LT 0.00000001)=0;
N.L(K,IG)$(ABS(N.L(K,IG))       LT 0.00000001)=0;
D.L(I)$(ABS(D.L(I))            LT 0.00000001)=0;
CX.L(I)$(ABS(CX.L(I))          LT 0.00000001)=0;
M.L(I)$(ABS(M.L(I))            LT 0.00000001)=0;
NKI.L$(ABS(NKI.L)              LT 0.00000001)=0;
LNFOR.L(LA)$(ABS(LNFOR.L(LA)) LT 0.00000001)=0;
KPFOR.L(K)$(ABS(KPFOR.L(K))    LT 0.00000001)=0;
GVFOR.L(G)$(ABS(GVFOR.L(G))       LT 0.00000001)=0;
*CNFOR.L$(ABS(CNFOR.L)         LT 0.0000001)=0;
*TP.L(H,G)$(ABS(TP.L(H,G))      LT 0.0000001)=0;
Y.L(Z)$(ABS(Y.L(Z))            LT 0.00000001)=0;
YD.L(H)$(ABS(YD.L(H))          LT 0.00000001)=0;
IGT.L(G,G1)$(ABS(IGT.L(G,G1)) LT 0.00000001)=0;
CH.L(I,H)$(ABS(CH.L(I,H))      LT 0.00000001)=0;
CG.L(I,G)$(ABS(CG.L(I,G))      LT 0.00000001)=0;
S.L(Z)$(ABS(S.L(Z))            LT 0.00000001)=0;
SPI.L$(ABS(SPI.L)              LT 0.00000001)=0;
*CPIH.L(H)$(ABS(CPIH.L(H))     LT 0.00000001)=0;

*-------------------------------------------------------------------------------------
* 4.2 INITIALIZATION OF VARIABLES AND REMOVING TRACE NUMBERS
*-------------------------------------------------------------------------------------

P.LO(I)=P.L(I)      / 1000;  P.UP(I)     = P.L(I)     * 1000;
PD.LO(I)=PD.L(I)     / 1000;  PD.UP(I)    = PD.L(I)    * 1000;
PVA.LO(I)=PVA.L(I)   / 1000;  PVA.UP(I)   = PVA.L(I)   * 1000;
RA.LO(F)=RA.L(F)     / 1000;  RA.UP(F)    = RA.L(F)    * 1000;
CPI.LO(H)=CPI.L(H)   / 1000;  CPI.UP(H)   = CPI.L(H)   * 1000;
CMI.LO(L)=CMI.L(L)   /1000;    CMI.UP(L)   = CMI.L(L)   *1000;
CMO.LO(L)=CMO.L(L)   /1000;    CMO.UP(L)   = CMO.L(L)   *1000;
*CPIH.LO(H)=CPIH.L(H) / 1000;  *CPIH.UP(H)  = CPIH.L(H) * 1000;
DS.LO(I)=DS.L(I)     / 1000;  DS.UP(I)    = DS.L(I)    * 1000;
DD.LO(I)=DD.L(I)     / 1000;  DD.UP(I)    = DD.L(I)    * 1000;
D.LO(I)=D.L(I)      / 1000;  D.UP(I)     = D.L(I)     * 1000;
V.LO(I)=V.L(I)      / 1000;  V.UP(I)     = V.L(I)     * 1000;
FD.LO(F,Z)=FD.L(F,Z)  / 1000;  FD.UP(F,Z)  = FD.L(F,Z)  * 1000;
HH.LO(H)=HH.L(H)     / 1000;  HH.UP(H)    = HH.L(H)    * 1000;
HW.LO(H)=HW.L(H)     / 1000;  HW.UP(H)    = HW.L(H)    * 1000;
HN.LO(H)=HN.L(H)     / 1000;  HN.UP(H)    = HN.L(H)    * 1000;
KS.LO(K,IG)=KS.L(K,IG)    / 1000;  KS.UP(K,IG)  = KS.L(K,IG)    * 1000;
*LAS.LO(LA)=LAS.L(LA)  / 1000;
*LAS.UP(LA) = LAS.L(LA) *1000;
LAS.LO(LA,IG)=LAS.L(LA,IG)  / 1000;  LAS.UP(LA,IG) = LAS.L(LA,IG) *1000;
M.LO(I)=M.L(I)      / 1000;  M.UP(I)     = M.L(I)     * 1000;
Y.LO(Z)=Y.L(Z)      / 1000;  Y.UP(Z)     = Y.L(Z)     * 1000;
YD.LO(H)=YD.L(H)     / 1000;  YD.UP(H)    = YD.L(H)    * 1000;
CH.LO(I,H)=CH.L(I,H)  / 1000;  CH.UP(I,H) = CH.L(I,H) * 1000;
CG.LO(I,G)=CG.L(I,G)  / 1000;  CG.UP(I,G)  = CG.L(I,G)  * 1000;
CN.LO(I)=0;
CX.LO(I)=CX.L(I)     / 1000;  CX.UP(I)    = CX.L(I)    * 1000;
N.LO(K,IG)=0;
* TP.LO(H,G)=TP.L(H,G)  / 1000;
* TP.UP(H,G)  = TP.L(H,G)  * 1000;
R.LO(F,IG)=R.L(F,IG)   / 1000;  R.UP(F,IG)   = R.L(F,IG)   * 1000;
```

```
*--------------------------------------------------------------------------------
* 5. PRE-MODEL CHECK OF PARAMETERS AND INITIAL VALUES OF VARIABLES
*--------------------------------------------------------------------------------
* 5.1 PRINTING OF CALCULATED PARAMETERS AND EXOGENOUS VARIABLES
*--------------------------------------------------------------------------------
OPTION DECIMALS=6;
DISPLAY  GAMMA, DELTA, JOBCOR, TAUF, TAUFH,TAUFL, TAUQ, TAUM, TAXS, ALPHA,
AG, AD, A, DO, CXO, MO, DDO,DSO,VO, VOT, FDO,RAO, CNOT, CNO, DEPR, CGO, CGOT, KSO,
NO, RHO, NO,RO, ALPHA, IGTO, TP, PIT, LFOR, KFOR, NKIO, CHO,CHOT,
YO, TAUV, TAUC, TAUN, TAUFX, TAUH, GVFORO, YO, A;

*--------------------------------------------------------------------------------
* 5.2 SAVING OF INITIAL VALUES FOR VARIABLES
*--------------------------------------------------------------------------------
* R1('GFREV',T)=Y.L('CALGF') + SUM(G, IGT.L('CALGF',G) );
* R1('SFREV',T)=SUM(GC, Y.L(GC) - IGT.L('CALGF',GC) );
* R1('STATIC',T)=0;
* R1('PIT',T)=SUM((GI,H), PIT.L(GI,H)*HH.L(H));
R1('SSC',T)= SUM(IG, R.L('LAND',IG) * RA.L('LAND') * FD.L('LAND',IG));
* R1('COMM',T)=SUM(F,CMI.L(F));
* R1('COMMO ',T)=SUM(F,CMO.L(F));
* R1('CMO',T)=CMO.L('L1');
* R1('CMI',T)=CMI.L('L1');
* R1('HC',T)=SUM(I, CH.L(I, 'HH5'))+ S.L('HH5')+ SUM(GI,PIT.L(GI,'HH5'))*HH.L('HH5')
R1('HC',T) = D.L('COMMU');
* R1('HC',T)=M.L('MANUF') ;
R1('SPI',T)=SPI.L;
R1('HH',T)=SUM(H, HH.L(H) );
R1('HN',T)=SUM(H, HN.L(H) );
R1('HW',T)=SUM(H, HW.L(H) );
R1('W',T)= RA.L('LAB');
R1('R',T)=SUM(Z, R.L('KAP',Z));
R1('RL',T)= RA.L('LAND');
R1('L',T)=SUM(Z, FD.L('LAB',Z) );
R1('K',T)=SUM(Z, FD.L('KAP',Z) );
R1('LAND',T)=SUM(IG, FDO('LAND',IG) );
* R1('LAS',T)=LAS.L('LAND');
* R1('LAND2',T)=SUM(Z, FD.L('LAND2',Z) );
* R1('GFSAV',T)=S.L('CALGF');

*--------------------------------------------------------------------------------
* 6. EQUATIONS
*--------------------------------------------------------------------------------
* 6.1 EQUATION DECLARATION
*--------------------------------------------------------------------------------
EQUATIONS

* HOUSEHOLDS
CPIEQ(H)     CONSUMER PRICE INDICES
* CPIHEQ(H)    HOUSING PRICE INDICES
YEQ(H)       HOUSEHOLD GROSS INCOMES
YDEQ(H)      HOUSEHOLD DISPOSABLE INCOMES
CHEQ(I,H)    PRIVATE CONSUMPTION
* CHHEQ(HD,H) PRIVATE HOUSING CONSUMPTION
SHEQ(H)      HOUSEHOLD SAVINGS

* PRODUCERS
PVAEQ(I)     VALUE ADDED
PFEQ(I)      PRODUCTION FUNCTION
FDEQ(F,I)    FACTOR DEMAND
VEQ(I)       INTERMEDIATE DEMAND
YFEQL(L)     LABOR FACTOR INCOME
YFEQK(K)     CAPITAL FACTOR INCOME
YFEQLA(LA)   LAND FACTOR INCOME
LANFOR(LA)   LAND INCOME OUTFLOW
KAPFOR(K)    CAPITAL INCOME OUTFLOW
GOVFOR(G)    GOVT OUTFLOW

* TRADE
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```
XEQ(I)        EXPORT DEMAND
DEQ(I)        DOMESTIC SHARES
MEQ(I)        IMPORT DEMAND
PEQ(I)        AGGREGATED PRICES
NKIEQ         NET CAPITAL INFLOW

* INVESTMENT
NEQ1(K,I)     GROSS INVESTMENT BY SECTOR OF DESTINATIONNEQ2(K,IG2)
CNEQ(I)       GROSS INVESTMENT BY SECTOR OF SOURCE
KSEQ(K,IG)    CAPITAL STOCK

* FACTOR SUPPLY
LSEQ1(H)       LABOR SUPPLY
LSEQ2(L)       COMMUTING INSUPPLY
LSEQ3(L)       COMMUTING  OUTSUPPLY
LASEQ1(LA,I)  LAND SUPPLY

* MIGRATION
 POPEQ(H)      POPULATION
ANEQ(H)        NUMBER OF NON WORKING HOUSEHOLDS


* GOVERNMENT
YGEQ(GX)       GOVERNMENT INCOME
CGEQ(I,GN)     GOVERNMENT ENDOGENOUS PURCHASES OF GOODS AND SERVICES
GFEQ(F,GN)    GOVERNMENT ENDOGENOUS RENTAL OF FACTORS
GSEQL(G)      GOVERNMENT SAVINGS
GSEQJ1(G)     GOVERNMENT SAVINGS
GSEQ(G)       GOVERNMENT SAVINGS
TDEQ(G,G1)    DISTRIBUTION OF TAXES
YGEQ1(GNL)
YGEQ2 (GT)
*REACF1EQ(F,G) REACTION FUNCTION EQUATION1


* MODEL CLOSURE
SPIEQ         STATE PERSONAL INCOME
LMEQ(L)       LABOR MARKET CLEARING
*HHEQ(H,HD) HOUSEHOLD L CLEARING
KMEQ(K,IG)    CAPITAL MARKET CLEARING
LAMEQ(LA,IG) LAND MARKET CLEARING
GMEQ(I)       GOODS MARKET CLEARING
DDEQ(I)       DEFINITION OF DOMESTIC DEMAND ;

*-----------------------------------------------------------------------------------------
* 6.2 EQUATION ASSIGNMENT
*-----------------------------------------------------------------------------------------

* HOUSEHOLDS

CPIEQ(H).. CPI(H)=E= SUM(I, P(I)  * ( 1 + SUM(GS, TAUC(GS,I) ) ) * CH(I,H) )
                     / SUM(I, PO(I) * ( 1 + SUM(GS, TAUQ(GS,I) ) ) * CH(I,H) );

YEQ(H).. Y(H)=E= SUM(L,  A(H,L) * HW(H) / SUM(H1, A(H1,L) * HW(H1) )
                 * (Y(L)+ (CMIWAGE(L)*CMI(L))) * ( 1 - SUM(G, TAUFL(G,L))))
                 + A(H, 'COMMO')*SUM(L,CMOWAGE(L)*CMOO(L))
                 + SUM(LA,  A(H,LA) * HW(H) / SUM(H1, A(H1,LA) * HW(H1))
                 * (Y(LA)+ LNFOR(LA) ) * ( 1 - SUM(G, TAUFLA(G,LA) ) ) )
                 + SUM(K,  A(H,K) * HW(H) / SUM(H1, A(H1,K) * HW(H1))
                 * (Y(K) + KPFOR(K)) * ( 1 - SUM(G, TAUFK(G,K) ) ) );

YDEQ(H).. YD(H)=E=   Y(H) + (PRIVRET(H) * HN(H))+ SUM(G, TP(H,G) * HN(H) )
                     - SUM(GI, PIT(GI,H)  * HH(H))
                     - SUM(G, TAUH(G,H)  * HH(H));

CHEQ(I,H).. CH(I,H)=E= CHO(I,H)
                     * ( ( YD(H)  / YDO(H)  ) / ( CPI(H) / CPIO(H) ) ) ** BETA(I,H)
                     * PROD(J, ( ( P(J)  * ( 1 + SUM(GS, TAUC(GS,J) ) ) )
                     / ( PO(J) * ( 1 + SUM(GS, TAUQ(GS,J) ) ) ) )** (LAMBDA(J,I)*1) ) ;
```

```
* CHHEQ(HD,H).. CHH(HD,H)=E= CHHO(HD,H)
*                        * ( ( YD(H)  / YDO(H)  )
*                          / (CPIH(H) / CPIHO(H) ) ** BETAH(HD, H)
*                        * PROD(HD1, ( ( P(HD1) * ( 1 + SUM(GS, TAUCH(GS,HD1))))
*                                / ( PO(HD1) * ( 1 + SUM(GS, TAUCH(GS,HD1)))))
*                          ** LAMBDAH(HD1,HD) ) ;

SHEQ(H).. S(H)=E= YD(H) - SUM(I, P(I) * CH(I,H) * ( 1 + SUM(GS, TAUC(GS,I) ) ));


* PRODUCERS
PVAEQ(I).. PVA(I) =E= PD(I) - SUM(J, AD(J,I) * P(J) * (1 + SUM(GS, TAUQ(GS, J) )) );

* PFEQ(I)..DS(I) =E= GAMMA(I) * SUM(F, ALPHA(F,I) * FD(F,I) **( - RHO(I))) ** ( -1 / RHO(I) );

PFEQ(I)..DS(I) =E= DELTA(I)*PROD(F$ALPHA(F,I),FD(F,I)**ALPHA(F,I));

FDEQ(F,I).. R(F,I) * RA(F) * ( 1 + SUM(GF,TAUFX(GF,F,I) ) ) * FD(F,I)
           =E= PVA(I) * DS(I) * ALPHA(F,I);

VEQ(I).. V(I) =E= SUM(J, AD(I,J) * DS(J) );

YFEQL(L).. Y('LAB') =E= SUM(IG, R('LAB',IG) * RA('LAB') * FD('LAB',IG));

YFEQK(K).. Y('KAP') =E= SUM(IG, R('KAP',IG) * RA('KAP') * FD('KAP',IG));

YFEQLA(LA).. Y('LAND') =E= SUM(IG, R('LAND',IG) * RA('LAND') * FD('LAND',IG));

LANFOR(LA).. LNFOR(LA) =E= LFOR(LA)*Y(LA);

KAPFOR(K).. KPFOR(K) =E= KFOR(K)*Y(K);


* TRADE
XEQ(I).. CX(I) =E= CXO(I)*( (PD(I)*(1+SUM(GK,TAUX(GK,I))))
                 /(PWO(I)*(1+SUM(GK,TAUQ(GK,I))))) **(ETAE(I)*1.0);

DEQ(I)$PWMO(I).. D(I) =E= DO(I) * ( PD(I) / PWMO(I)/(1+SUM(GK,TAUM(GK,I)))) ** ETAD(I);

MEQ(I).. M(I)=E= ( 1 - D(I) ) * DD(I);

PEQ(I).. P(I)=E= D(I) * PD(I) + ( 1 - D(I) ) * PWMO(I)*(1+SUM(GK,TAUM(GK,I))) ;

NKIEQ.. NKI =E= SUM(I, M(I) * PWMO(I) ) - SUM(I, CX(I) * PD(I) )- SUM(H, PRIVRET(H)*HN(H))
       - SUM(LA, LNFOR(LA))- SUM(K, KPFOR(K))
       - SUM(G, GVFOR(G))- SUM(L,CMOWAGE(L)*CMOO(L)) -  SUM(L,CMIWAGE(L)*CMI(L)) ;


* INVESTMENT
NEQ1(K,I).. N(K,I)=E= NO(K,I)*( R(K,I)/RO(K,I)) ** ETAIX(K,I)
                    * ( DS(I) / DSO(I))**(ETAIX(K,I)*1.1);

NEQ2(K,IG2).. N(K,IG2)=E= NO(K,IG2)*( R(K,IG2)/RO(K,IG2)) ** ETAIX(K,IG2)
                    * ( Y(IG2)/ YO(IG2) )**(ETAIX(K,IG2)*1.1);

CNEQ(I).. P(I)* ( 1 + SUM(GS, TAUN(GS,I) ) )  * CN(I) =E= SUM(IG, B(I,IG) * (SUM(K, N(K,IG))) );

KSEQ(K,IG).. KS(K,IG)=E= KSO(K,IG) * ( 1 - DEPR) + N(K,IG) ;


* FACTOR SUPPLY
LSEQ1(H).. HW(H)/HH(H) =E= HWO(H)/HHO(H)   * (( SUM(L, RA(L) / RAO(L))/ ( CPI(H) / CPIO(H) ) )
                 * (SUM((Z,L), FD(L ,Z) )/(SUM(H1, HW(H1)* JOBCOR(H1,'LAB'))+CMI('LAB')))
                 +(EXWGE('LAB') / RA('LAB') )* (CMO('LAB')/ (SUM(H1, HW(H1)
                 * JOBCOR(H1,'LAB'))+CMI('LAB')))) ** ((ETARA(H))*3.0)
                 * ( SUM(G, TP(H,G) / CPI(H)) / SUM(G, TP(H,G) / CPIO(H) ) ) ** ETAPT(H);

LSEQ2(L).. CMO(L)=E= CMOO(L)* (((EXWGE(L) / RA(L) ))** ECOMO(L));
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LSEQ3(L).. CMI(L)=E= CMIO(L)* (((RA(L) / EXWGE(L)))** ECOMI(L));

LASEQ1(LA,I)..  LAS(LA,I) =E=  LASO(LA,I)*(R(LA, I)/RO(LA, I))**(ETAL(LA,I)*2.5)
                               * ( DS(I) / DSO(I))**(ETAL(LA,I)*.77);


* MIGRATION
POPEQ(H).. HH(H)=E= HHO(H) * NRPG(H)
                          + MIO(H) * ( ( YD(H)   / HH(H)   )
                                   / ( YDO(H)  / HHO(H)  )
                                    / ( CPI(H)  / CPIO(H) ) ) ** ETAYD(H)
                                   * ( ( HN(H)   / HH(H)   )
                                    / ( HNO(H)  / HHO(H)  ) ) ** ETAU(H)
                          - MOO(H) * ( ( YDO(H)  / HHO(H)  )
                                    / ( YD(H)   / HH(H)   )
                                    / ( CPIO(H) / CPI(H)  ) ) ** ETAYD(H)
                                    * ( ( HNO(H)  / HHO(H)  )
                                   / ( HN(H)   / HH(H)   ) ) ** ETAU(H);

ANEQ(H).. HN(H)=E= HH(H) - HW(H);


* GOVERNMENT


YGEQ(GX).. Y(GX)=E=   SUM(I, TAUV(GX,I) * V(I) * P(I) )
                     + SUM(I, TAUX(GX,I)* CX(I) * PD(I))
                     + SUM(I, TAUM(GX,I) * M(I)*PWMO(I))
                     + SUM((H,I), TAUC(GX,I) * CH(I,H) * P(I) )
                     + SUM(I, TAUN(GX,I) * CN(I) * P(I) )
                     + SUM((GN,I), TAUG(GX,I) * CG(I,GN) * P(I) )
                     + SUM((F,I), TAUFX(GX,F,I) * RA(F) * R(F,I) * FD(F,I) )
                     + SUM((F,GN), TAUFX(GX,F,GN) * RA(F) * R(F,GN) * FD(F,GN) )
                     + SUM(L, TAUFH(GX,L) * (Y(L) + CMIWAGE(L)*CMI(L)))
                     + SUM(K, TAUFH(GX,K) * (Y(K)) )
                     + SUM(LA, TAUFH(GX,LA) * (Y(LA)) )
                     + SUM(H, PIT(GX,H) * HH(H) )
                     + SUM(H, TAUH(GX,H) * HH(H) )
                     + SUM(GX1, IGT(GX,GX1));

YGEQ2(GT).. Y(GT)=E= SUM(GX, IGT(GT,GX));

YGEQ1(GNL)..  Y(GNL)=E=TAXS1(GNL)*Y('CYGF');

REACF1EQ(F,G)..  Y('LAND','CNPRP')=E=  SUM(('LAND',I), TAUFX('CNPRP','LAND',I)
                     * RA('LAND') * R('LAND',I) * FD('LAND',I) )- AG(I,GN) * (Y(GN);

GOVFOR(G).. GVFOR(G) =E= GFOR(G)*Y(G);

CGEQ(I,GN).. P(I) * ( 1 + SUM(GS, TAUG(GS,I) ) ) * CG(I,GN)
               =E= AG(I,GN) * (Y(GN)+ GVFOR(GN));

GFEQ(F,GN)..  FD(F,GN) * R(F,GN) * RA(F)*( 1 + SUM(GF, TAUFX(GF,F,GN)))
               =E= AG(F,GN) * (Y(GN)+ GVFOR(GN));


GSEQL(GN).. S(GN)=E=(Y(GN)+ GVFOR(GN))-SUM(I, CG(I,GN)*P(I)*( 1 + SUM(GS, TAUG(GS,I))))
               - SUM(F, FD(F,GN) * R(F,GN) * RA(F) * ( 1 + SUM(GF, TAUFX(GF,F,GN))));

GSEQ(GX).. S(GX)=E= (Y(GX)+GVFOR(GX)) - SUM(H, (TP(H,GX) * HN(H)) ) - SUM(G,IGT(G,GX) );

GSEQJ1('CYGF').. S('CYGF')=E= Y('CYGF') -  Y('CYGF');

TDEQ(G,GX)$(IGTD(G,GX) EQ 1)..IGT(G,GX) =E= TAXS(G,GX) *( Y(GX)
                                   + GVFOR(GX)- SUM(H, (TP(H,GX) * HN(H))));


* MODEL CLOSURE
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```
SPIEQ.. SPI =E=  SUM(H, Y(H) )+ SUM((H,G), TP(H,G) * HN(H)  ) + SUM(H, PRIVRET(H)*HN(H));

LMEQ(L).. SUM(H, HW(H)* JOBCOR(H,L)) + CMI(L) =E= SUM(Z, FD(L ,Z) )+ CMO(L);

* LMEQ(L,IG).. SUM(H, HW(H)* JOBCOR(H,L))=E= FD(L ,IG);

* HHEQ(H,HD).. SUM(H, HH(H) * HOUSECOR(H,HD)) =E= SUM(LA, LAS(LA,HD));

KMEQ(K,IG).. KS(K,IG) =E= FD(K,IG);

* LAMEQ(LA).. LAS(LA) =E= SUM(IG, FD(LA,IG)) ;

* KMEQ(K).. SUM(K,KS(K,IG)) =E= SUM(K,FD(K,IG));

LAMEQ(LA,IG).. LAS(LA,IG) =E= FD(LA,IG) ;

GMEQ(I).. DS(I)=E= DD(I) + CX(I) - M(I);

DDEQ(I).. DD(I)=E= V(I) + SUM(H, CH(I,H) ) + SUM(G, CG(I,G) ) + CN(I);

*-----------------------------------------------------------------------------------------
* 6.3 MODEL CLOSURE
*-----------------------------------------------------------------------------------------
* LBFOR.FX = LBFORO;
*  P.FX(FG)= PO(FG);
* FIX PIT FOR NON INCOME TAX UNITS TO ZERO
* PIT.FX(G,H)$(NOT GI(G))=0;

* FIX INTER GOVERNMENTAL TRANSFERS TO ZERO IF NOT IN ORIGINAL SAM
  IGT.FX(G,GX)$(NOT IGTO(G,GX))=0;

* FIX EXOGENOUS INTERGOVERNMENTAL TRANSFERS
IGT.FX(G,GX)$(IGTD(G,GX) EQ 2)=IGTO(G,GX);

* FIX GOVERNMENT DEMAND FOR EXOGENOUS GOVERNMENT UNITS
* CG.FX(I,GX)=CGO(I,GX);
* FD.FX(F,'STFED')=FDO(F,'STFED');

* FIX INTER SECTORAL WAGE DIFFERENTIALS
  R.FX(L,Z)=RO(L,Z);
* R.FX(LA,Z)=RO(LA,Z);
* R.FX(K,Z)=RO(K,Z);


* FIX GOVERNMENT RENTAL RATE FOR CAPITAL TO INITIAL LEVEL
* R.FX(K,G)=RO(K,G);

* FIX ECONOMY WIDE SCALAR
* RA.FX(L)=RAO(L);
  RA.FX(LA)=RAO(LA);
  RA.FX(K)=RAO(K);

* FIX EXOGENOUS TRANSFER PAYMENT LEVELS
*TP.FX(H,GWX)=TPO(H,GWX);
*TP.FX(H,G)$(NOT TPO(H,G))=0;

*FIXING THE AMOUNT OF LAND
*LAS.FX(LA,IG) = LASO(LA,IG);

*-----------------------------------------------------------------------------------------
* 7. SOLVE AND OUTPUT PREPARATION
*-----------------------------------------------------------------------------------------

MODEL FTCO /ALL/;

* SIMMULATION LOOP

 LOOP(T$(ORD(T) GT 1),
  IF (
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(ORD(T)) >2,
* CX.L('CMANF') = 1170.0;
* CXO(I) = CXO(I)*1.003;
* LASO(LA,IG)=LASO(LA,IG)*1.00;
*   MOO(H)=MOO(H)*.914;
*  CXO('LODGE') = CXO('LODGE')*1.04;
*   CXO('RETAL') = CXO('RETAL')*1.053;
*  CXO('EATING') = CXO('EATING')*1.017;
*    HHO(H) = HHO(H)*1.012462923;
*  FD.FX('LAB', 'STFED')=FD.L('LAB', 'STFED');
*       FD.FX('MANUF')=1.0;
*   TAUC('CYSTX', I)=  TAUC('CYSTX', I)*1.05; DISPLAY TAUQ, TAUC;
*   TAUX('CYSTX', I)=  TAUX('CYSTX', I)*1.05;
*  TAUV('CYSTX', I)=  TAUV('CYSTX', I)*1.05;
*   TAUN('CYSTX', I)=  TAUN('CYSTX', I)*1.05;
*   TAUG('CYSTX', I)=  TAUG('CYSTX', I)*1.05;
*  PWO('MANUF') = PWO('MANUF')*1.07;
*   PWMO('RETAL') = PWMO('RETAL')*1.04;
*   DELTA('RETAL')=DELTA('RETAL')*1.0028;
*  PWO('LODGE') = PWO('LODGE')*1.05;
*  DELTA('LODGE') = DELTA('LODGE')*1.017;
*  PWO('eating') = PWO('eating')*1.03;
*  ALPHA('LAB','LODGE') =  ALPHA('LAB','LODGE')+.004;
*  ALPHA('KAP','LODGE') =  ALPHA('KAP','LODGE')-.002;
*  ALPHA('LAND','LODGE') =  ALPHA('LAND','LODGE')-.002;
*  LASO(LA,IG) =  LASO(LA,IG)*1.0019;
*  KSO(K,'RETAL') =  KSO(K,'RETAL')*1.01;
   NRPG(H) = NRPG(H)*1.0047;
*   EXWGE(L) = EXWGE(L)*1.02;
  )


OPTION NLP=MINOS5;
FTCO.scaleopt = 1;
FTCO.OPTFILE = 0;
OPTION SYSOUT = ON;
SOLVE FTCO MAXIMIZING SPI USING NLP;

*  R1('GFREV',T)=Y.L('CALGF') + SUM(G, IGT.L('CALGF',G) );
*  R1('SFREV',T)=SUM(GC, Y.L(GC) - IGT.L('CALGF',GC) );
*  R1('STATIC',T)=TXE(T,'CABAC') + TXE(T,'CAPIT') + TXE(T,'CALSU');
*  R1('PIT',T)=SUM((GI,H), PIT.L(GI,H)*HH.L(H));
*  R1('DSF',T)=R1('SFREV',T) - R1('SFREV','TODAY');
*  R1('DDRE',T)=R1('DGF',T) + R1('DSF',T) - R1('STATIC',T);
*  R1('PDRE',T)$R1('STATIC',T)=R1('DDRE',T) / R1('STATIC',T) * 100;
*  R1('COMM',T)=SUM(F, CMI.L(F));
R1 ('SPI',T) = SPI.L;
*  R1('COMMO',T)=SUM(F,CMO.L(F));
*  R1('CMO',T)=CMO.L('L1');
*  R1('CMI',T)=CMI.L('L1');
*  R1('GN',T)=SUM(I, N.L(I) )   + SUM(L, CMI.L(L))*JOBCOR('HH1')- SUM(L, CMO.L(L))*JOBCOR('HH1');
R1('SSC',T)= SUM(IG, R.L('LAND',IG) * RA.L('LAND') * FD.L('LAND',IG));
R1('HC',T) = D.L('COMMU');
*  R1('HC',T) = SUM(IG,LAS.L('LAND',IG));
*  R1('HC',T)=M.L('MANUF') ;
*  R1('HC',T)=SUM(I, CH.L(I, 'HH5'))+ S.L('HH5')+ SUM(GI,PIT.L(GI,'HH5'))*HH.L('HH5')
R1('HH',T)=SUM(H, HH.L(H) );
R1('HN',T)=SUM(H, HN.L(H) );
R1('HW',T)=SUM(H, HW.L(H) );
R1('W',T)= RA.L('LAB');
R1('R',T)=SUM(Z, R.L('KAP',Z));
R1('RL',T)= RA.L('LAND');
R1('L',T)=SUM(Z, FD.L('LAB',Z) );
R1('K',T)=SUM(Z, FD.L('KAP',Z) );
R1('LAND',T)=SUM(Z, FD.L('LAND',Z) );
*  R1('GFSAV',T)=S.L('CALGF');
R2('M-STAT',T)=FTCO.MODELSTAT;
R2('S-STAT',T)=FTCO.SOLVESTAT);
```

```
DFCG.L(I,G)=CG.L(I,G)-CGO(I,G);
DFFD.L(F,Z) = FD.L(F,Z)-FDO(F,Z);
DY.L(Z) = Y.L(Z)-YO(Z);
DM.L(I) =M.L(I)-MO(I);
DDS.L(I) = DS.L(I)-DSO(I);
DDD.L(I) =DD.L(I) - DDO(I);
DCX.L(I) =CX.L(I) -CXO(I);
GCP1.L(I) =SUM(H, CH.L(I,H))+ CN.L(I)+ SUM(GN, CG.L(I,GN))+ CX.L(I)-M.L(I);
DGCP1.L(I) = GCP1.L(I) - GCP10(I);
DCH.L(I,H) = CH.L(I,H) - CHO(I,H);
GCP.L =SUM((I,H), (CH.L(I,H)))+ SUM(I, CN.L(I))+ SUM((I,GN), (CG.L(I,GN)))
      + SUM(I, CX.L(I))-SUM(I, M.L(I));
DGCP.L=GCP.L-GCPO;

OPTION DECIMALS=6;
DISPLAY   CGO,CG.L,CHO,CH.L,CNO,CN.L,CPIO,CPI.L,CXO,CX.L,DO,D.L,DDO,DD.L,DSO,
DS.L,FDO,FD.L,HHO,HH.L,HNO,HN.L,HWO,HW.L,IGTO,IGT.L,KSO,KS.L,LASO,LAS.L,MO,M.L,
NO,N.L,NKIO,NKI.L,LNFORO,LNFOR.L,KPFORO,KPFOR.L,GVFORO,GVFOR.L, PO,P.L,PDO,
PD.L,PVAO,PVA.L, PWMO, RAO,RA.L,RO,R.L,SO,S.L,SPIO,SPI.L,TP,VO,V.L,YO,Y.L,YDO,YD.L,
DFCG.L, DFFD.L, DY.L, DM.L, DDS.L, DDD.L, DCX.L, DGCP1.L, GCP1.L, dgcp.L, GCP.L,
GCPO,CMDO, CMO.L, cmiO, CMI.L;



* PUT RESULTS INTO OUTPUT FILE
* results.pc=5;
PUT 'FTCO              ';
LOOP(T, PUT T.TL);
PUT /;

PUT '                           ',' MODEL    ','           ';
       LOOP(T$(ORD(T) GT 1), LOOP(MS$(R2('M-STAT',T) EQ ORD(MS) ), PUT MS.TL ) );
       PUT /;

PUT '                           ',' SOLVER   ', PUT '           ';
       LOOP(T$(ORD(T) GT 1), LOOP(SS$(R2('S-STAT',T) EQ ORD(SS) ), PUT SS.TL ) );
       PUT /;

LOOP(R1H, PUT '           ';
       PUT R1H.TL,
       LOOP(T, PUT R1(R1H,T) );
       PUT / );
```